1999-2001 CHOLLAS CREEK WATERSHED MONITORING

Final Report

Prepared For:

The City of San Diego
1970 B Street, MS27A
San Diego, California 92102

Department of Pesticide Regulation
1001 I Street, P.O. Box 4015
Sacramento, California 95812

MEC ANALYTICAL SYSTEMS, INC.

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Preface

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Department of Pesticide Regulation. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

This is a report of research performed by MEC Analytical Systems, Inc. in conjunction with other contractors. This research was funded by the California Department of Pesticide Regulation, the City of San Diego, the San Diego Regional Water Quality Control Board, and the San Diego Unified Port District.

Acknowledgements

This study was conducted through a coordinated effort. MEC managed this study and conducted monitoring activities for the 2000/2001 storm season and the first flush storm event of the 2001/2002 storm season. MEC synthesized all the project data, interpreted results and presented the findings.

The URS Corporation managed water quality sampling and monitoring for this project in the 1999/2000 storm season and the 2000 dry weather season. In the 2000/2001 storm season, URS assisted MEC in sample collection activities.

AMEC Earth and Environmental conducted bioassay testing for this study.

Aqua-Science conducted ELISA organophosphate chemistry analysis.

Babcock Laboratories conducted metals and hardness chemistry analysis.

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Table of Contents

Executive Summary

The City of San Diego, the Port of San Diego, the San Diego Regional Water Quality Control Board, and the California Department of Pesticide Regulation funded the study of organophosphate pesticides and metals in the Chollas Creek watershed from 1999 to 2001. On behalf of the City of San Diego, MEC Analytical Systems, Inc. managed the study efforts from 2000-2001 and analyzed the information collected during the course of the study. This report presents the findings from all surveys conducted during this study and assesses those results in an attempt to:

1. Understand the relationship between toxicity effects and chemical concentrations measured in storm water in Chollas Creek, and
2. Identify if any region or reach within the Chollas Creek watershed is a source of contaminant(s).

Sampling surveys consisted of two storm events in the 1999-2000 wet weather season, one dry weather event in fall of 2000, two storm events in the 2000-2001 wet weather season, and one storm event in the 2001-2000 wet weather season. A total of five storms were sampled. These storm events yielded a total of 34 sets of results for statistical evaluation of the relationships between organophosphate pesticides, total and dissolved metals, and toxicity. Samples were analyzed for total hardness, calcium, magnesium, diazinon, chlorpyrifos, and the total and dissolved fractions of copper, lead, and zinc, and toxicity to the amphipod *Hyalella azteca* and the cladoceran *Ceriodaphnia dubia*. Of the storm events monitored, four storms were in the middle of the storm season and one storm was the first flush of the storm season.

An analysis of the results from this study led to several conclusions that are summarized below:

Conclusion 1: Contaminants measured were ubiquitous throughout the watershed. The concentration of contaminants measured and toxicity to test species varied from storm to storm throughout the watershed. Each station varied from storm to storm without a consistent pattern in the watershed. No single station or area of the watershed could be identified as the source of contaminant(s).

Conclusion 2: The first flush storm of the season had the highest toxicity effects throughout the watershed at each station and the highest concentrations of diazinon detected at all stations. The mean concentrations of total metals for all stations was highest during the first flush storm event, however the mean concentrations of dissolved metals was not considerably greater during the first flush event than other storms monitored. Concentrations of chlorpyrifos during the first flush storm were within the range of concentrations observed during each storm event.

Conclusion 3: Toxicity to *C. dubia* is linked to diazinon in the watershed. A correlation between toxicity to *C. dubia* and diazinon concentrations was observed for this study after collecting the fifth storm event. It took a total of 34 samples to obtain this correlation $r^2 = 0.7032$. This supports the findings of the toxicity identification evaluation coordinated by the Southern California Coastal Waters Research Project (SCCWRP) in 1999.

While the results varied from storm to storm and from reach to reach some trends were observed. It should be noted, however, that these trends within the watershed should be considered with caution as they were observed over only five storms monitored. The following are observations that were made during the course of this study.

Observation 1: Chlorpyrifos concentrations were greater in the west tributary of the south fork of Chollas Creek and in the downstream reach of the south fork of Chollas Creek.

Observation 2: Diazinon and total copper concentrations exceeded chronic water quality criteria during the majority of storm events throughout all of Chollas Creek.

Observation 3: Total lead concentrations exceeded acute water quality criteria during the majority of storm events throughout all of Chollas Creek.

Observation 4: Total zinc concentrations are did not exceed water quality criteria during a majority of the storm events in the lower reaches of the north fork of Chollas Creek, downstream of the east and west tributaries. This may be due to a dilution effect as water reaches this location. Upstream in both the east and west tributaries to the north fork, total zinc concentrations exceeded chronic water quality criteria during many of the storm events.

Observation 5: Dissolved metals concentrations were low throughout all of Chollas Creek with the exception of dissolved copper concentrations in the east tributary of the north fork of the creek, which had dissolved copper levels in exceedance of the acute water quality criteria for all but one storm event.

Observation 6: A relationship between diazinon and total copper concentrations to *C. dubia* mortality was observed. The data indicates a relationship of greater than 20% mortality when concentrations of diazinon are greater than 0.4 µg/L and copper concentrations are greater than 40 µg/L (with the exception of one outlier point). It is interesting that this relationship is observed with total copper and not dissolved copper, as dissolved metals are the biologically available forms. It is possible that total copper is a surrogate for some other constituent. Additional research would be required to confirm this relationship and the associated concentration thresholds.

Observation 7: During this study the toxicity of storms to *C. dubia* varied widely from storm to storm. Whereas the storm water was consistently toxic to *H. azteca,* yet a correlation between *H. azteca* toxicity and any analyte tested was not observed in this study.

Section 1: Introduction

Chollas Creek is listed as a Clean Water Act Section 303(d) impaired water body for metals, coliform bacteria, and diazinon. Concentrations of specific metals and coliforms as well as toxicity to test organisms found during storm water sampling for the City of San Diego Copermittees' Storm Water Monitoring Program are the basis of the 303(d) listing. The San Diego Regional Water Quality Control Board is developing a Total Maximum Daily Load (TMDL) for copper, lead, zinc, and diazinon in Chollas Cheek.

The TMDL is being developed because levels of copper, lead, zinc, and diazinon did not meet water quality objectives (SDRWQCB 1999). The numeric water quality criteria for copper, lead, and zinc in Chollas Creek were determined using the Code of Federal Regulations, Title 40 Part 131.38 (40 CFR 131.38), also known as the California Toxics Rule (CTR). These three metals have exceeded water quality criteria established in the CTR in many of the storm water samples collected by the City of San Diego Copermittees' Stormwater Monitoring Program since 1994. The California Department of Fish and Game developed a Water Quality Criterion (WQC) for diazinon. Numeric targets for diazinon are based on this WQC.

1.1 Watershed Monitoring History

Storm water monitoring has been conducted in the north fork of Chollas Creek since the 1993-1994 storm season at a mass loading station [SD8(1)] established for the City of San Diego Copermittees' Storm Water Monitoring Program under the MS4 permit. This mass loading station has been sampled during the wet weather season each year since it was established.

The analytical chemistry and toxicity data from this monitoring resulted in the placement of Chollas Creek on the 303(d) list as an impaired water body. Further, the sediments at the mouth of Chollas Creek where it empties into receiving waters of San Diego Bay have been identified as a Toxic Hot Spot under the Bay Protection Toxic Cleanup Program. The mouth of Chollas Creek in San Diego Bay is also on the 303(d) list for benthic community degradation and sediment impairment.

In 1999, Southern California Coastal Water Research Project (SCCWRP) coordinated a study to characterize the storm water toxicity in Chollas Creek using the Toxicity Identification Evaluation procedure (TIE). This study found that organophosphate pesticides were responsible for toxicity in the freshwater test organism (*Ceriodaphnia dubia*) used and trace metals were responsible for toxicity in the marine test organism (purple sea urchin). SCCWRP made the following recommendations for further study:

- Additional TIE testing be conducted to confirm toxicants.
- Further research be conducted to establish a link between creek measurements and impairments in the receiving waters.
- Source tracking be conducted using both toxicological and chemical testing (SCCWRP 1999).

Based on these recommendations, the watershed stakeholders collaborated to conduct a focused study that provides information upstream in the Chollas watershed. Funding by California Department of Pesticide Regulation supported this effort. Studies conducted to date consist of two wet-weather and one dry-weather survey performed in 2000 and three wet-weather surveys performed in 2001. Testing done on these surveys included analysis of diazinon; chlorpyrifos; the metals copper, lead, and zinc; general chemical constituents; and toxicity tests.

1.2 Monitoring Objective

The objective of this study is to answer specific questions relating to contaminant sources and provide a link between toxicity and chemistry. The monitoring questions this study attempts to answer are:

- Is there a relationship between toxicity effects and chemical concentrations measured in the storm water?
- Can a region or reach of the watershed be identified as a source area of contaminant(s)?

This monitoring study provides additional data to characterize the contaminants within the reaches of the watershed for the TMDL. This data report incorporates results from previous studies conducted by other contractors to support statistical data evaluation and source identification analyses.

1.3 Overview of the Watershed Monitoring Program

This watershed monitoring program was initiated in the 1999-2000 storm season. Sampling during this season consisted of six stations sampled during two storm events. Samples were collected as flow weighted composites. Sampling events were collected mid-storm season in February 2000. Diazinon and chlorpyrifos were analyzed on only three of the six sites in the initial storm sampled and in five of the sites sampled on the second storm sampled. Toxicity testing was conducted on three samples collected in the initial storm sampled, and four samples collected in the second storm sampled. General chemistry and metals were analyzed at all six stations sampled in each storm event.

In fall 2000, dry weather samples were collected and analyzed at four locations in Chollas Creek. Samples were collected as grab samples. These samples were tested for diazinon, chlorpyrifos, general chemistry, metals, and toxicity at all five locations.

The monitoring for the Chollas Creek watershed wet weather season 2000-2001 and the first flush of the 2001-2002 season consisted of nine stations. Samples were collected as flow weighted composites. Samples were analyzed for the general chemical constituents of total hardness, calcium, and magnesium, and for total and dissolved fraction concentrations of the metals copper, lead, and zinc. Samples also were analyzed for the pesticides diazinon and chlorpyrifos. Acute toxicity tests were performed using the amphipod *Hyalella azteca* and the cladoceran *Ceriodaphnia dubia*.

The first flush sampling of the 2001-2002 season included the analysis for total suspended solids. This test was added to the analyte list in an attempt to observe if a relationship between toxicity to organisms and total suspended solids was observed.

Section 2: Study Area Description

2.1 Watershed Area

The Chollas Creek watershed is highly urbanized with a total acreage of 20,807. Much of the watershed is residential (12,764 acres). The remainder of the land use is divided up into commercial (3601 acres), open space (2160 acres), transportation (1454 acres), and industrial (828 acres). The watershed is located in south San Diego and drains directly into San Diego Bay. A map of the watershed is located in Figure 2.1.

2.2 Station Location Description

Sampling was conducted at nine sites along Chollas Creek during the 2000-2001 season. The sampling sites may be broken down into two general areas: north fork and south fork. North fork locations include SD8(1), SD8(2), SD8(3), DPR(3), and DPR(4). South fork locations include SD8(5), SD8(6), DPR(1), and DPR(2). The sites and locations are pictured below, along with a brief description.

SD8(1) Main Chollas Channel - This City of San Diego Copermittees' Storm Water Monitoring Program mass loading station is in a concrete-lined channel, in a residential area. This north fork location is south of Imperial Avenue, at the end of the 3300 block of Durant Street. The channel runs along the west side of Interstate (I) 15. This site has the longest sampling history of all sites.

SD8(2) Wabash Avenue Branch of the Main Chollas Channel – Located just north of the State Highway (SH) 94 and I-15 interchange, this is a City of San Diego field-screening site. It is in the north fork and consists of a natural channel running along I-15, through the I-805 interchange, where it then splits and follows each freeway to approximately Landis Street. Some of the vegetation in this portion of the watershed is protected under the Multiple Species Conservation Plan.

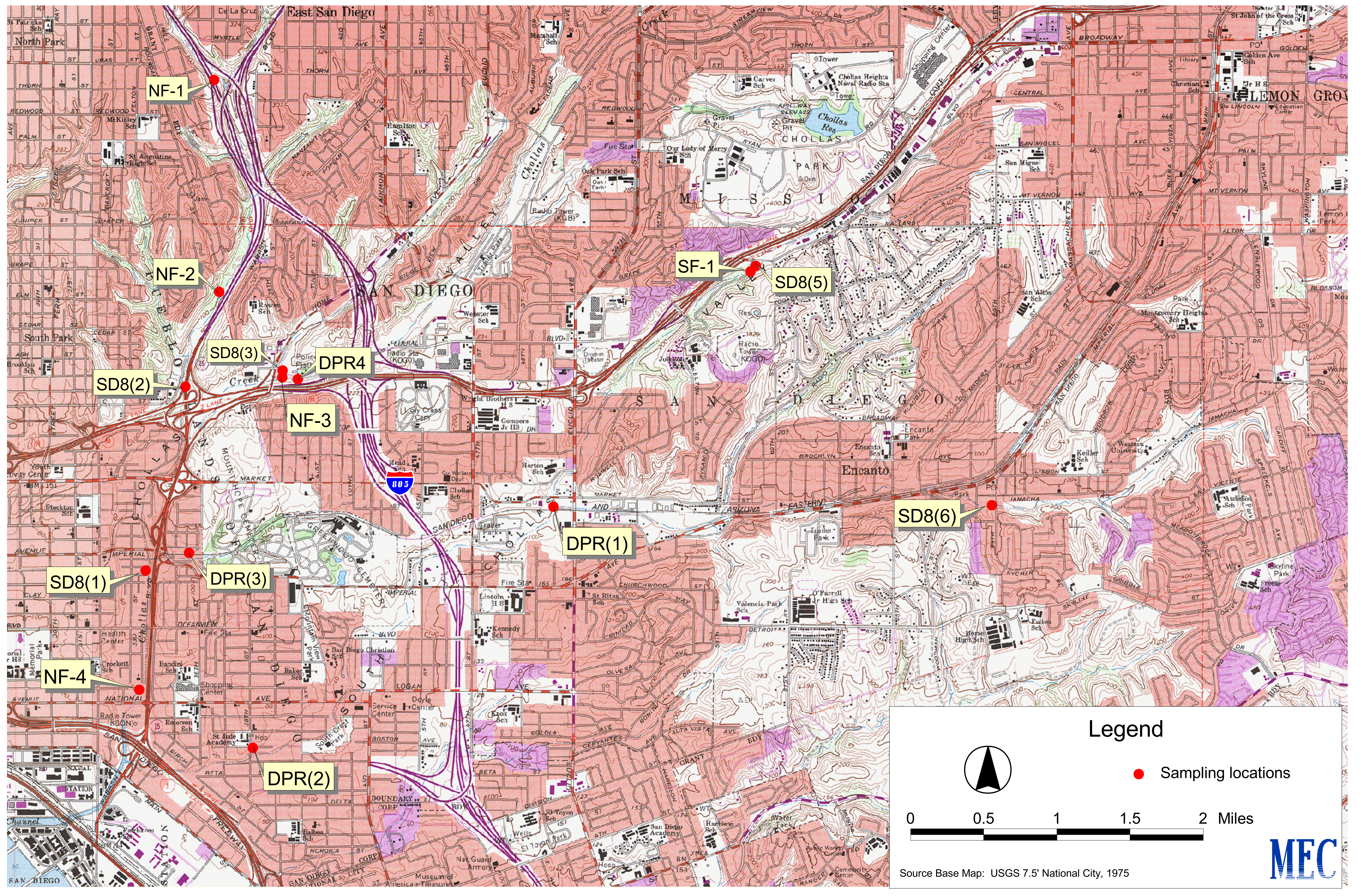


Figure 2.1. Chollas Creek Watershed Map.

SD8(3) Home Avenue Branch of the Main Chollas Creek Channel – This is also a City of San Diego field-screening site, and is located next to the San Diego Police Department Canine Training Field. This portion of the creek is channeled, but has a natural bottom. This location also falls within the north fork of Chollas Creek. This area tends to remain wet year-round as a result of irrigation runoff from upstream residential areas.

SD8(5) Federal Boulevard Branch of South Chollas Creek – This south fork site is located next to SH- 94, west of 60th Street and Federal Boulevard, in a light industrial/commercial area near the edge of San Diego City limits. Discharges from the City of Lemon Grove pass through here.

SD8(6) Jamacha Road Branch of South Chollas Creek – This south fork site is located along a natural portion of the creek, within a residential area, and is downstream of a City of San Diego field-screening site. The sampling point is situated just south of Jamacha Road at the creek crossing on 69th Street. This location is typically wet all year long.

DPR(1) – This south fork site is located west of Euclid Avenue, just north of the San Diego and Arizona Eastern train tracks. The nearest major cross street to Euclid Avenue is Market Street.

DPR(2) – This south fork site is located at the 38th Street Bridge over Chollas Creek, just north of Alpha Street, and a few blocks east of I-5. National Avenue, a few blocks north of the site, is the nearest major cross street to 38th Street.

DPR(3) – Situated on the north fork of Chollas Creek, this site is just downstream (west) of Mount Hope and Greenwood Cemeteries, before the main stem of Chollas Creek. It is north of Imperial Avenue, and east of I-15.

DPR(4) – This north fork site, on a different branch of the creek than DPR (3), is located just south of Federal Boulevard, west of I-805, and east of Home Avenue. It is adjacent to a police shooting range.

2.3 Watershed Monitoring History

Chollas Creek has been monitored as a part of the City of San Diego Copermittees' NPDES Storm Water Monitoring Program at location SD8(1) since the 1993-1994 wet weather season. The results of the analytical testing from that monitoring program relative to this TMDL study are described below.

Values from previous monitoring data for the target analytes are summarized by parameter and date in Table 2.1. Dissolved metal data were collected between November 1994 and April 2000. Dissolved copper concentrations varied from <0.005 to 0.034 mg/L; dissolved lead was <0.001 to 0.018 mg/L, and dissolved zinc was between 0.008 and 0.141 mg/L. Data for total metals are available for February 1994 to April 2000. Total copper ranged from <0.005 to 0.085 mg/L, total lead ranged from <0.001 to 0.14 mg/L, and total zinc ranged from <0.025 to 0.56 mg/L. Only one value has been reported in previous monitoring reports for chlorpyrifos at this site. The concentration of chlorpyrifos was 0.1 µg/L for a sample taken in November 1998. Diazinon results are available for two samples, which were collected in November 1998 and January 1999. Both values were 0.46 µg/L. Toxicity data using *Pimephales promelas* are available for samples taken between February 1995 and January 1999 and using *Ceriodaphnia dubia* between November 1994 and March 2000. LC_{50} values were all >100% for *P. promelas* and 17.7 to >100% for *C. dubia*.

Table 2.1. Historical Storm Water Monitoring Results at Chollas Creek Mass Loading Station SD(8).

DATE	COPPER	LEAD	ZINC
DISSOLVED METALS			
11/10/1994	0.013 mg/L	0.0026 mg/L	0.07 mg/L
1/11/1995	<0.005 mg/L	<0.001 mg/L	0.014 mg/L
2/14/1995	0.0054 mg/L	<0.001 mg/L	0.012 mg/L
4/16/1995	0.0097 mg/L	<0.001 mg/L	0.069 mg/L
11/1/1995	NA	NA	NA
1/22/1996	0.012 mg/L	0.002 mg/L	<0.025 mg/L
1/31/1996	0.008 mg/L	0.002 mg/L	0.032 mg/L
3/5/1996	0.034 mg/L	0.018 mg/L	0.141 mg/L
12/9/1996	0.01 mg/L	0.015 mg/L	0.08 mg/L
1/16/1997	0.02 mg/L	0.007 mg/L	0.04 mg/L
2/12/2000	<0.005 mg/L	<0.001 mg/L	0.019 mg/L
3/5/2000	<0.005 mg/L	<0.001 mg/L	0.028 mg/L
4/17/2000	<0.005 mg/L	<0.005 mg/L	0.008 mg/L
TOTAL METALS			
2/17/1994	0.034 mg/L	0.11 mg/L	0.26 mg/L
3/24/1994	0.029 mg/L	0.14 mg/L	0.24 mg/L
4/24/1994	0.044 mg/L	0.07 mg/L	0.32 mg/L
11/10/1994	0.036 mg/L	0.035 mg/L	0.18 mg/L
1/11/1995	0.017 mg/L	0.044 mg/L	0.15 mg/L
2/14/1995	0.04 mg/L	0.11 mg/L	0.36 mg/L
4/16/1995	0.085 mg/L	0.14 mg/L	0.56 mg/L
11/1/1995	0.046 mg/L	0.0229 mg/L	<0.025 mg/L
1/22/1996	NA	NA	NA
1/31/1996	NA	NA	NA
3/5/1996	NA	NA	NA
12/9/1996	0.02 mg/L	0.016 mg/L	0.07 mg/L
1/16/1997	0.01 mg/L	0.058 mg/L	0.2 mg/L
11/10/1997	0.017 mg/L	0.003 mg/L	0.176 mg/L
12/6/1997	0.028 mg/L	<0.042 mg/L	0.11 mg/L
3/14/1998	0.028 mg/L	0.095 mg/L	0.092 mg/L
11/8/1998	0.006 mg/L	<0.001 mg/L	0.03 mg/L
1/25/1999	<0.005 mg/L	0.007 mg/L	0.048 mg/L
3/15/1999	0.015 mg/L	0.082 mg/L	0.21 mg/L
2/12/2000	0.029 mg/L	0.015 mg/L	0.096 mg/L
3/5/2000	0.016 mg/L	<0.001 mg/L	0.05 mg/L
4/17/2000	0.014 mg/L	<0.005 mg/L	0.08 mg/L

PESTICIDES/PCBs		
DATE	CHLORPYRIFOS	DIAZINON
11/8/1998	0.1 µg/L	0.46 µg/L
1/25/1999	NA	0.46 µg/L

NA=not analyzed

Table 2.1. Continued.

Pimephales promelas 7-Day Toxicity			
DATE	LC50	NOEC (% survival)	NOEC (% growth)
2/14/1995	>100	>100	<6.25
1/22/1996	>100	>100	50
2/1/1996	>100	100	100
3/5/1996	>100	30	30
12/9/1996	>100	100	100
1/16/1997	>100	100	100
11/10/1997	>100	100	67
12/6/1997	>100	100	100
11/8/1998	>100	100	<20
1/25/1999	>100	100	44Q

Ceriodaphnia dubia 7-Day Toxicity			
DATE	LC50	NOEC (% survival)	NOEC (% reproduction)
11/11/1994	17.7	12.5	25
1/11/1995	50	25	50
2/14/1995	35.4	25	50
4/16/1995	37.5	25	50
1/22/1996	71	50	50
3/5/1996	55	30	30
12/9/1996	39	30	30
1/16/1997	54	44	<23
11/10/1997	33	23	23
12/6/1997	54	44	44
11/8/1998	44.8	44	<20
1/25/1999	67	67	67Q
3/15/1999	54	67	67
2/12/2000	78.5	67	44
2/21/2000	>100	100	100
3/5/2000	>100	100	100

Q = Qualified as estimated

Sources: Kinnetics Laboratories Inc. (1994, 1995); Woodward-Clyde (1996, 1997, 1998); URS Greiner Woodward- Clyde (1999, 2000).

To assist in the TMDL, the City of San Diego, the Regional Water Quality Control Board, and the EPA Department of Pesticide Regulation initiated a watershed study in the 1999-2000 storm season, which consisted of six stations. In fall 2000, a dry weather study was performed at five other stations in the watershed. In 2000-2001, wet weather sampling was conducted at a total of nine stations (the 6 original wet-weather stations from 1999-2000 and 3 additional stations).

Sampling conducted in the 1999-2000 wet-weather season and the 2000 dry season is summarized below. Sampling conducted in the 2000-2001 wet-weather sampling (present study) is described in Section 3.

WET WEATHER SAMPLING, 1999-2000
Samples were collected at six sites on February 12 and 21-23, 2000. Three sites- SD8(1), SD8(2), SD8(3)- were sampled along the north fork of Chollas Creek, and three sites- SD8(4), SD8(5), and SD8(6)- were sampled along the south fork of Chollas Creek. Samples were analyzed for various physical and chemical constituents. Physical analyses included pH, specific conductance, total dissolved solids (TDS), total suspended solids (TSS), turbidity, chemical oxygen demand (COD), oil and grease, surfactants (Methylene Blue Active Substances), total hardness, calcium, and magnesium. Nutrients analyzed were total Kjeldahl nitrogen (TKN), nitrate, nitrite, ammonium, and total and dissolved phosphorus. Total metals analyzed were antimony, chromium, arsenic, cadmium, copper, lead, nickel, selenium, and zinc. Dissolved metals analyzed were antimony, arsenic, cadmium, chromium, lead, copper, nickel, zinc, and selenium. Diazinon and chlorpyrifos were analyzed in three samples collected on February 12 and five samples collected on February 21. Acute toxicity tests were conducted on the February 12 and 21 samples using the cladoceran *Ceriodaphnia dubia*, the amphipod *Hyalella azteca*, and the fathead minnow *Pimephales promelas*. A summary of the results can be found in the report- *Chollas Creek Water Quality Sampling 1999-2000 Wet-Weather Season* (URS 2000c).

DRY WEATHER SAMPLING, 2000
Dry weather sampling was conducted on September 1, 2000, just two days after a rain event. This sampling event did not collect what is traditionally considered dry weather flow, but rather collected ponded water remaining following a storm event. The sampling was conducted at four sites along the north fork of Chollas Creek; NF-1, NF-2, NF-3, and NF-4. One site along the south fork was sampled SF-1.

The five samples were analyzed for diazinon and chlorpyrifos, calcium, copper, magnesium, lead, zinc, and total hardness. Acute bioassay tests were conducted using *C. dubia* and *H. azteca*. Samples collected at site NF-4 exhibited total hardness, calcium, magnesium, and copper concentrations significantly higher than all other sites. NF-4 also showed rapid and complete mortality of *C. dubia*. It was suggested that high measurements of salinity and total hardness at NF-4 may have contributed to the mortality. A summary of the results can be found in the report- *Chollas Creek Water Quality Sampling 2000-2001 Season-First Sampling Event* (URS 2000b).

Section 3: 2000-2001 Wet Weather Monitoring Activities

In the 2000-2001 storm season, nine different sites were sampled along the branches of Chollas Creek. Five sites -SD8(1), SD8(2), SD8(3), SD8(5), and SD8(6)- had been sampled in 1999-2000. Four sites- DPR(1), DPR(2), DPR(3), and DPR(4)- were added for the 2000-2001 wet-weather monitoring. The SD8 sites were found using locations identified on maps provided in URS (2000c). DPR sites were located using information from the standard agreement between the City of San Diego and the Department of Pesticide Regulation. Global Positioning System (GPS) coordinates were recorded at all sites (Table 3.1).

Table 3.1. Station coordinates.

Site	Coordinates	
	Latitude	Longitude
SD8(1)	32 42.2914	117 07.2995
SD8(2)	32 43.0917	117 07.1140
SD8(3)	32 43.1619	117 06.6055
SD8(5)	32 43.6324	117 04.1844
SD8(6)	32 42.6029	117 02.9650
DPR(1)	32 42.5800	117 05.2081
DPR(2)	32 41.5268	117 06.7421
DPR(3)	32 42.3695	117 07.0772
DPR(4)	32 43.1257	117 06.5275
NF1	33 44.3943	117 06.9894
NF2	32 43.4988	117 06.9376
NF3	32 43.1148	117 06.6236
NF4	32 41.7769	117 07.3257
SF1	32 43.6044	117 04.6241

3.1 Sampling Dates and Rainfall

Samples were taken during three rain events, January 8, February 13-14, and November 12, 2001. The January 8 event measured 0.31 inches of precipitation and lasted for 21 hours and 50 minutes. The February 13-14 event measured 0.82 inches and lasted 31 hours and 18 minutes. The November 12 event was the first flush event of the 2001-2002 storm season. There had been no measured runoff since April 2001. The November 12 event measured 0.19 inches of precipitation and lasted 3 hours. Rainfall measurements were obtained for this watershed from the ALERT rain-gauge at Fashion Valley 32. Storm event hydrographs are shown in Appendix A.

3.2 Sample Collection Methods

Prior to the initial storm on January 8, 2001, flow meters were installed at all sites. Once rain began, grab samples were collected at each of the nine sites using 12-quart polypropylene buckets. Personnel began to collect grab samples once sufficient flow occurred within each channel to collect water samples. Powder-free latex exam gloves were worn while sampling. The quantity of water collected was dependent on the level of flow. In general, when flow heights were low, less water was collected. At higher flow levels more water was collected. Multiple samples were collected at each site over the course of the storm. The number of samples collected were dependent upon the duration of the storm. Three samples were collected during the January 8 event, five samples were collected during the February 13-14 event, and five samples were collected during the November 12 event. The collection time was noted for each sample and was later correlated with the flow.

Samples from the bucket were poured into 1-gallon glass jars. Laboratories verified that sample jars were cleaned before usage. Temperature and pH were measured immediately after collection and recorded on data sheets. Once the first sample had been collected at all sites, the procedures were repeated over the duration of the rain event.

Data sheets included time of sampling, location and repetition number, pH, and temperature. Sample jars were labeled with sample location, date of collection, time, and jar number with total number of jars collected. Jars were stored in coolers with ice until delivery to the laboratory. Chains-of-custody were also completed and accompanied the samples. For the January 8 collection, the samples were delivered to EnviroMatrix Analytical, Inc (EMA) for compositing. The samples were brought back to MEC Analytical Systems, Inc. for compositing for the February 13-14 and November 12 surveys.

Flow Weight Compositing

Grab samples were composited by site at the laboratories. Aliquots from each sample were composited using a calculation dependent on flow rate at the collection site and volume of sample collected. A lower flow rate represented a smaller part of the storm and therefore, a lower volume of the sample taken at that time would be used for the composite. Higher flow rates represented a larger portion of the storm, and greater volumes of these samples were put in the composite. In some instances a limited amount of sample collected at a particular site would determine the final composite volume. This would lead to different volumes for the final composites at the various sites while keeping the ratios accurate. By compositing samples based on volume and flow, a flow-weight composite of the storm event was created. Aliquots were poured into a pre-cleaned graduated cylinder for accurate measurement and then transferred into a 5-gallon, pre-cleaned carboy. From the carboy, the samples were transferred to appropriate containers for shipment to various laboratories for analyses.

3.3 Laboratory Analyses

Aqua-Science Environmental Toxicology Consultants analyzed samples for chlorpyrifos and diazinon. Analyses were performed using Enzyme-Linked Immunosorbant Assay (ELISA). E.S. Babcock & Sons, Inc. analyzed samples for total hardness, calcium, and magnesium using EPA Method 200.7 and for copper, lead, and zinc using EPA Method 200.8. AMEC Earth & Environmental performed the bioassay tests. A 96-hour acute test was performed using the amphipod *Hyalella azteca*. Another 96-hour acute test was performed using the cladoceran *Ceriodaphnia dubia*.

Section 4: Monitoring Results

4.1 Water Quality Criteria for Chollas Creek

The water quality criteria for metals and diazinon were established for the TMDL by the SDRWQCB for Chollas Creek. The freshwater criteria for copper, lead, and zinc are expressed as a function of hardness using the California Toxic Rule (CTR) and an average hardness estimate of 100 mg/L. The Criteria Maximum Concentration (CMC) are the acute criteria that estimate the highest concentration of a material in surface water at which an aquatic community can be briefly exposed without resulting in an unacceptable effect. The Criteria Continuous Concentration (CCC) are chronic criteria that estimate the highest concentration of a material in surface water at which an aquatic community can be indefinitely exposed without resulting in an unacceptable effect. The USEPA recommends that freshwater criteria for metals be expressed in terms of dissolved metal concentrations in the water.

For total copper, the numeric targets are 14 μg/L for the CMC and 9.3 μg/L for the CCC. The dissolved concentration targets for copper are 13 μg/L for the CMC and 9.0 μg/L for the CCC. For total lead, numeric targets are 82 μg/L for the CMC and 3.2 μg/L for the CCC. For dissolved lead, numeric targets are 65 μg/L for the CMC and 2.5 μg/L for the CCC. For total zinc, the numeric targets are 120 μg/L for the CMC and 120 μg/L for the CCC. For dissolved zinc, the numeric targets are 120 μg/L for the CMC and 120 μg/L for the CCC.

Numeric targets for diazinon are based on the California Department of Fish and Game water quality criterion (WQC) for the protection of freshwater aquatic organisms from diazinon. The acute target concentration for diazinon is 0.08 μg/L for a one-hour average. The chronic target concentration is 0.05 μg/L for a four-day average. The frequency of allowed exceedance is once every three years on average.

4.2 Summary of 2000-2001 Wet Weather Results

<u>Toxicity Tests</u>

Acute toxicity tests on the January 8, February 13, and November 12, 2001 samples were performed using *C. dubia* and *H. azteca*. Percent survival and LC_{50} results from these tests are summarized together with results from 1999-2000 wet and 2000 dry samples in Table 4.1. For the January 8, 2001 survey, at 100 percent concentration, survival of *C. dubia* was very low, from 0 to 5 percent, at six sites- SD8(1), SD8(2), SD8(3), SD8(5), DPR(1), and DPR(2). The LC_{50} at these six sites ranged from 59 to 87 percent concentration. Survival ranged from 55 to 80 percent at three sites- DPR(3), DPR(4), and SD8(6), and the LC_{50} at these sites was greater than 100 percent concentration. For the February 13, 2001 samples, survival of *C. dubia* was comparatively high, ranging from 95 to 100 percent at eight sites- SD8(1), SD8(2), SD8(3), SD8(5), SD8(6), DPR(1), DPR(3), and DPR(4). Survival was lowest, 55 percent, at DPR(2). The LC_{50} was measured at greater than 100 percent at all sites for the February 13, 2001 survey. The first flush sampling event of November 12, 2001 was the most toxic to *C. dubia* of all the storms sampled. With the exception of site SD8(5), survival of *C. dubia* in 100 percent concentration of the stormwater runoff was 0 percent. At SD8(5) survival was good at 90 percent. The LC_{50} at SD8(5) was greater than 100 percent. The LC_{50} at the other sites during this first flush event ranged from 25 to 84 percent.

Table 4.1. 2000-2001 Wet Weather Toxicity Results.

Station	% Survival in 100% Concentration			LC_{50}		
	1/8/2001	2/13/2001	11/12/2001	1/8/2001	2/13/2001	11/12/2001
Ceriodaphnia dubia						
SD8(1)	0	100	0	59	>100	25
SD8(2)	5	100	0	86	>100	25
SD8(3)	0	100	0	59	>100	25
SD8(5)	0	100	90	81	>100	>100
SD8(6)	55	100	0	>100	>100	25
DPR(1)	0	100	0	59	>100	65
DPR(2)	0	55	0	87	>100	58
DPR(3)	80	95	0	>100	>100	84
DPR(4)	65	100	0	>100	>100	61
Hyalella azteca						
SD8(1)	2	66	4	36	>100	33
SD8(2)	0	18	2	39	68	27
SD8(3)	26	22	0	50	52	65
SD8(5)	14	36	22	38	78	49
SD8(6)	28	84	16	38	>100	49
DPR(1)	28	6	72	67	36	>100
DPR(2)	32	34	26	71	82	69
DPR(3)	40	88	78	85	>100	>100
DPR(4)	12	52	10	52	>100	37

For the January 8 survey, survival of *H. azteca* ranged from 0-40 percent at 100 percent concentration. The LC_{50} ranged from 36 to 85 percent concentration. For the February 13 survey, survival ranged from 6 to 36 percent for five sites- SD8(2), SD8(3), SD8(5), DPR(1), and DPR(2) at 100 percent concentration. The LC_{50} at these five sites ranged from 36 to 82 percent. Survival ranged from 52 to 88 percent at four sites- SD8(1), SD8(6), DPR(3), and DPR(4), and the LC_{50} was greater than 100 percent concentration. The first flush sampling event of November 12, 2001 resulted in toxicity effects in *H. azteca* ranging from 78 to 0 percent survival in 100% concentration of stormwater. The LC_{50} at DPR(1) and DPR(3) was greater than 100 percent for the November storm, and at the other sites the LC_{50} ranged from 27 to 69 percent.

<u>Total Metals</u>

Total metal concentrations are summarized in Table 4.2. Total recoverable concentrations were measured for copper, lead, and zinc for the January 8, February 13, and November 12 surveys. Copper concentrations ranged from 32 to 70 µg/L for the January 8 survey, from 10 to 41 µg/L for the February 13 survey, and from 32 to 180 µg/L for the November 12 survey. Total lead concentrations ranged from 19 to 91 µg/L for the January 8 survey, from 9 to 61 µg/L for the February 13 survey, and from 12 to 270 µg/L for the November 12 survey. Total zinc concentrations ranged from 160 to 660 µg/L for the January 8 survey, from 55 to 280 µg/ for the February 13 survey, and from 180 to 1900 µg/L for the November 12 survey.

Table 4.2. 2000-2001 Wet Weather Total Metals Results.

Station	Copper (µg/L)			Lead (µg/L)			Zinc (µg/L)		
	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01
SD8(1)	65	15	97	83	22	94	480	100	740
SD8(2)	52	16	49	91	29	39	420	100	370
SD8(3)	65	15	45	90	21	52	480	110	300
SD8(5)	37	33	180	29	59	170	260	270	1900
SD8(6)	32	10	49	19	9	36	160	55	290
DPR(1)	32	17	170	27	23	270	190	120	1400
DPR(2)	56	41	32	59	61	19	360	280	180
DPR(3)	36	19	37	21	18	12	230	110	200
DPR(4)	70	38	42	68	53	29	660	280	340
CMC (acute criteria)	14			82			120		
CCC (chronic criteria)	9.3			3.2			120		

Colored values exceed water quality criteria, California Toxic Rule
Red shaded values exceed CMC (acute) criteria
Yellow shaded values exceed CCC (chronic) criteria

Dissolved Metals

Dissolved metal concentrations were measured for copper, lead, and zinc for the January 8, February 13, and November 12 surveys (Table 4.3). Copper concentrations ranged from 8 to 19 µg/L for the January 8 survey, from 3 to 34 µg/L for the February 13 survey, and from 4 to 19 µg/L for the November 12 survey. Lead concentrations ranged from 1 to 3 µg/L for the January 8 survey, from non-detect to 46 µg/L for the February 13 survey, and from non-detect to 3 µg/L for the November 12 survey. Dissolved zinc concentrations ranged from 87 to 290 µg/L for the January 8 survey, from 32 to 370 µg/L for the February 13 survey, and from 40 to 130 µg/L in the November 12 survey.

Table 4.3. 2000-2001 Wet Weather Dissolved Metals Results.

Station	Copper (µg/L)			Lead (µg/L)			Zinc (µg/L)		
	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01
SD8(1)	11	4	5	3	<1	<1	87	32	62
SD8(2)	12	5	18	1	1	<1	160	36	130
SD8(3)	19	5	5	1	2	3	130	36	47
SD8(5)	13	5	4	1	2	<1	290	68	73
SD8(6)	13	3	6	1	<1	<1	170	33	76
DPR(1)	13	8	6	1	27	<1	200	250	40
DPR(2)	13	5	11	1	1	<1	180	66	55
DPR(3)	17	34	19	2	46	2	220	370	100
DPR(4)	8	5	10	1	4	2	230	46	110
CMC (acute criteria)	13			65			120		
CCC (chronic criteria)	9.0			2.5			120		

Colored values exceed water quality criteria, California Toxic Rule
Red shaded values exceed CMC (acute) criteria
Yellow shaded values exceed CCC (chronic) criteria

General Chemistry

General chemistry constituents measured on the surveys included total hardness, magnesium, and calcium (Table 4.4). Total hardness ranged from 68 to 640 mg/L for the January 8 survey, from 35 to 110 mg/L for the February 13 survey, and from 58 to 370 mg/L for the November 12 survey. Magnesium ranged from 5 to 68 mg/L for the January 8 survey, from 3 to 13 mg/L for the February 13 survey, and from 5 to 36 mg/L for the November 12 survey. Calcium ranged from 19 to 140 mg/L for the January 8 survey, from 7 to 20 mg/L for the February 13 survey, and from 15 to 89 mg/L for the November 12 survey. For the January 8 survey, SD8(6) reported much higher results than all other sites.

Table 4.4. 2000-2001 Wet Weather General Chemistry Results.

Station	Hardness (mg/L)			Magnesium (mg/L)			Calcium (mg/L)		
	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01
SD8(1)	170	45	200	16	4	18	42	11	51
SD8(2)	68	37	58	5	3	5	19	9	15
SD8(3)	87	40	300	8	4	35	22	10	60
SD8(5)	200	52	310	22	6	27	41	11	78
SD8(6)	640	91	280	68	10	29	140	20	64
DPR(1)	210	48	370	20	6	36	49	10	89
DPR(2)	150	110	100	16	13	9	34	20	25
DPR(3)	73	35	73	6	4	7	19	7	18
DPR(4)	160	69	72	15	7	6	40	16	19

Diazinon and Chlorpyrifos

Diazinon and chlorpyrifos were analyzed for the January 8, February 13, and November 12 samples. Results are summarized in Table 4.5. Diazinon concentrations ranged from 0.3709 to 0.8086 µg/L for the January 8 survey, from 0.0748 to 0.4624 µg/L for the February 13 survey, and from 0.6146 to 1.3743 µg/L for the November 12 survey. Chlorpyrifos concentrations ranged from 0.0630 to 0.1103 ppb for the January 8 survey, from 0.0165 to 0.0611 ppb for the February 13 survey, and from 0.0500 to 0.0972 µg/L for the November 12 survey. Concentrations of diazinon were highest at all sites in the November 12 (first flush) survey. However, chlorpyrifos concentrations were not consistently higher at all sites for this first flush sampling event compared to other storm events sampled.

Table 4.5. 2000-2001 Organophosphate Pesticide Results.

Station	Chlorpyrifos (µg/L)			Diazinon (µg/L)		
	1/8/01	2/13/01	11/12/01	1/8/01	2/13/01	11/12/01
SD8(1)	0.0870	0.0467	0.0972	0.7783	0.2381	1.0527
SD8(2)	0.0630	0.0293	0.0630	0.5312	0.3441	1.0397
SD8(3)	0.0743	0.0520	0.0738	0.642	0.2051	0.6146
SD8(5)	0.0920	0.0535	0.0527	0.8086	0.2184	0.9043
SD8(6)	0.0684	0.1646	0.0509	0.5234	0.4101	1.0932
DPR(1)	0.0820	0.0354	0.0514	0.7899	0.2765	0.8794
DPR(2)	0.0840	0.0483	0.0550	0.5173	0.4624	1.3743
DPR(3)	0.1103	0.0460	0.0500	0.3709	0.0748	0.6257
DPR(4)	0.1040	0.0611	0.0650	0.5932	0.3221	0.6222
Acute WQC				0.08		
Chronic WQC				0.05		

WQC = Water quality criteria
Colored values exceed diazinon water quality criteria
Red shaded values exceed acute water quality criteria
Yellow shaded values exceed chronic water quality criteria

4.3 Data Comparisons and Statistical Analysis

The data from the five separate sampling events was compiled and analyzed to provide an indication of which branches of Chollas Creek (if any) had greater contaminant loads. The data included in concentration comparisons and statistical analysis are the 1999-2000 wet-weather monitoring (URS 2000c), the 2000-2001 wet-weather monitoring, and the dry-weather monitoring (URS 2000b). The data comparisons were conducted using three different tools, which are described below.

<u>Data Map Plots</u>

Maps of the Chollas Creek watershed were created for each sampling event and concentrations of contaminants were plotted using symbols on individual maps for each contaminant and each sampling event. These data map plots were created to provide a visual representation of contaminant concentrations at each site for each event. This tool provides a visual observation of trends. For example, if a specific sampling site contributed consistently higher or lower concentrations of a contaminant or exhibited consistently greater toxicity to organisms the trend would be visually observed. Data map plots are presented as Figures 4.1 – 4.13. A discussion of observations is provided in Section 4.4. Data results from all surveys are presented in Tables 4.6 – 4.10.

<u>Ranking by Watershed Area</u>

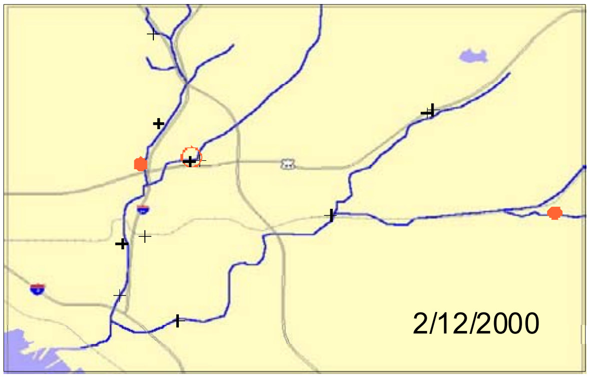
To further elucidate results and relative contribution by watershed area, the chemical data was converted to a numerical rank based upon the established water quality standards for Chollas Creek. The numerical rankings were grouped geographically according to south and north fork sections of the creek. The mean contaminant rank by creek fork was calculated to identify high contaminant areas vs. low contaminant areas. This information is presented in Table 4.13. A discussion of this analyses is provided in Section 4.5.

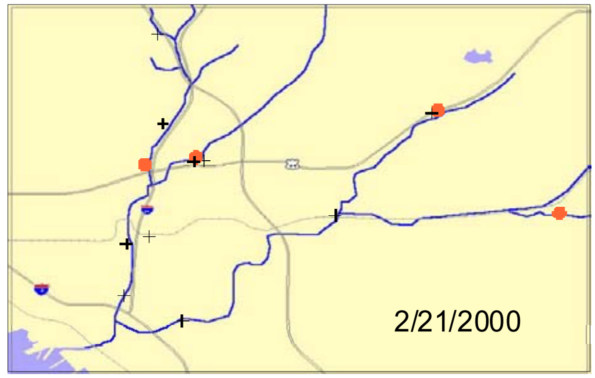
<u>Statistical Linear Regression</u>

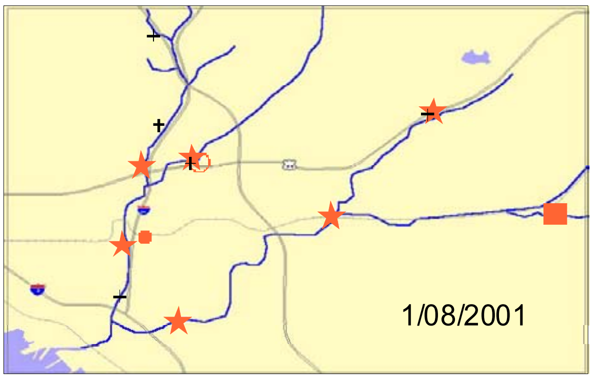
Statistical linear regression analyses were performed to evaluate correlations between organism toxicity and chemical concentration. The results of regression analysis are provided in Section 4.5 and Table 4.14.

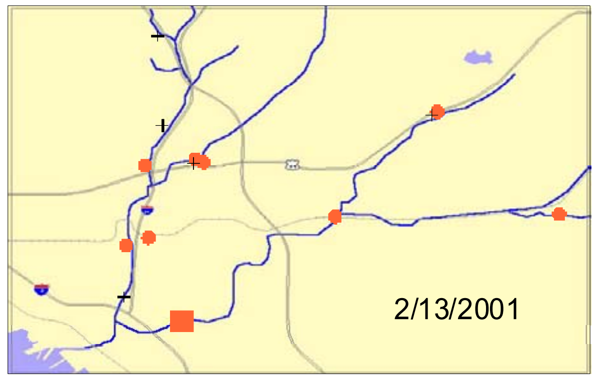
Comparison of the data sets has the following limitations. In the 1999-2000 sampling event six sites were analyzed compared to nine in the present 2000-2001 sampling effort. Unfortunately, some of the 1999-2000 sampling sites were not analyzed for various reasons (samples not delivered to the correct lab, broken samples, etc.) so the data set varies among analytes. Samples from February 12, 2000 SD8(5) were not delivered to the analyzing laboratory for toxicity testing. Sampling for DPR(2) [formerly SD8(4)] was performed on February 23, 2000 instead of February 21, 2000. Samples from site SD8(1) and DPR(2) were analyzed by a different laboratory than the other sites and had different detection limits. Therefore, the detection limits vary according to the analyzing laboratory and this impacts data comparability.

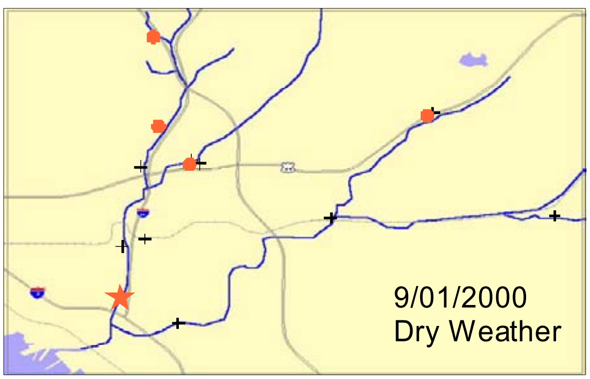
In the 2000-2001 sampling effort, it is important to note that the Viejas fire may have influenced storm water runoff contaminants. This fire occurred on January 3, 2001, and burned 10,000 acres prior to the January 8, 2001 sampling effort. Effects from this fire were noticed throughout San Diego County in the form of falling ash and it can be assumed that the storm water runoff also contained burn ash. Although metals and organophosphate pesticides were detected at higher concentrations and greater mortality was observed for both *C. dubia* and *H. azteca* during this sampling event (1/8/01), the concentration ranges of chemical contaminants were still within the previously measured concentration range for analyses conducted since 1994 at the watershed mass loading station [SD8(1)].











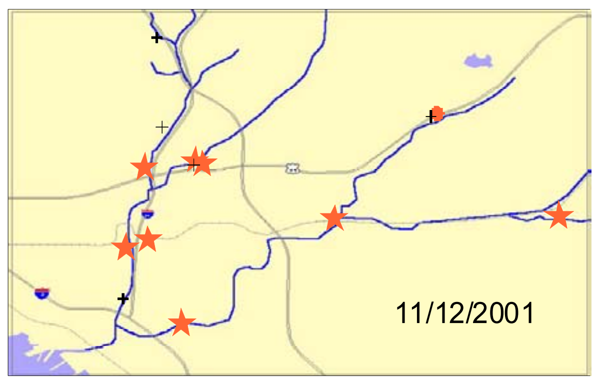
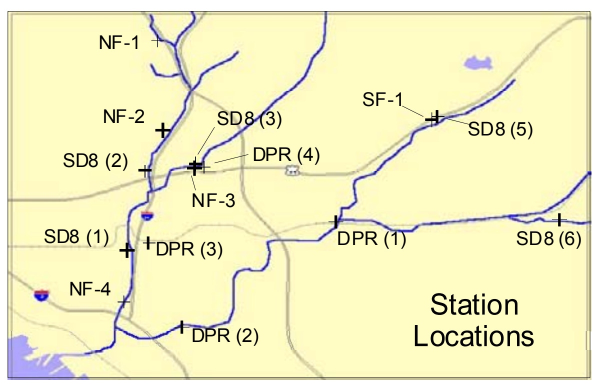


FIGURE 4.1
Ceriodaphnia % Mortality in 100% Concentration

- + Not Sampled
- 0% - 20%
- 20% - 40%
- 40% - 60%
- 60% - 80%
- 80% - 100%



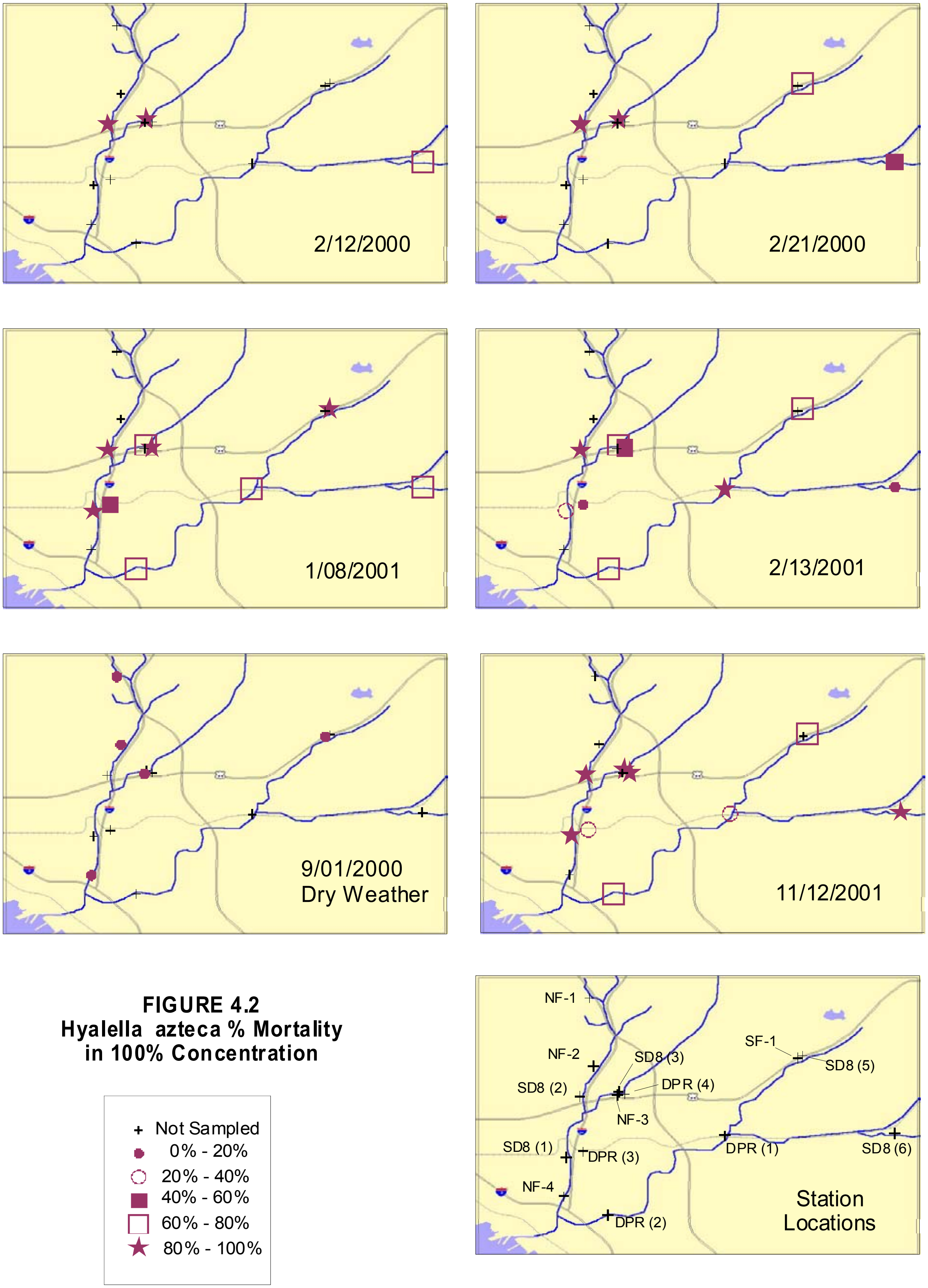
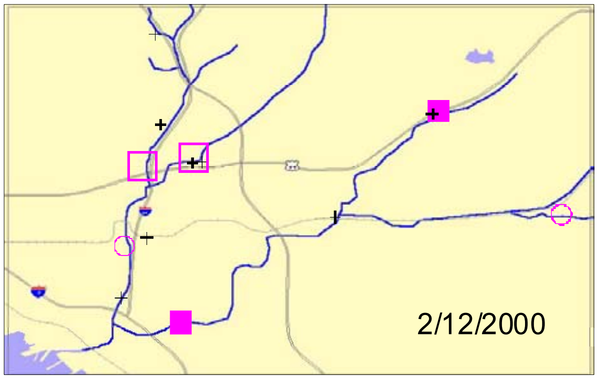
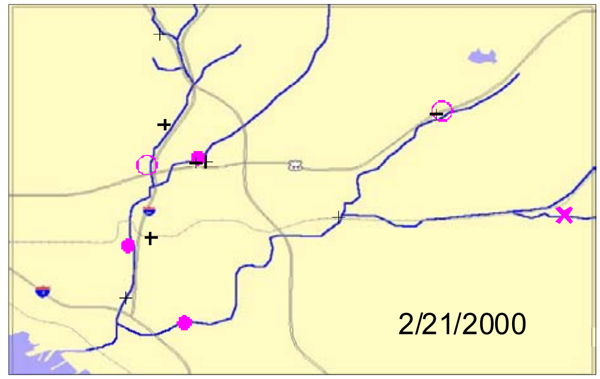
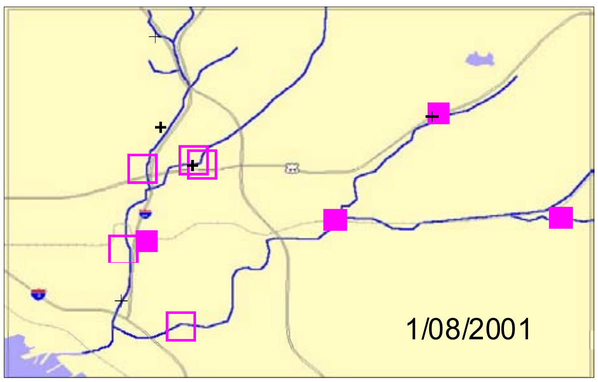
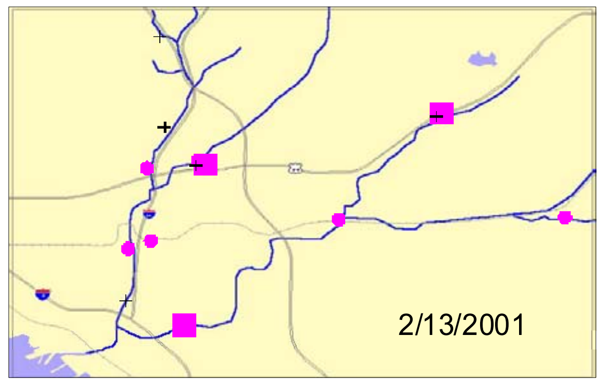


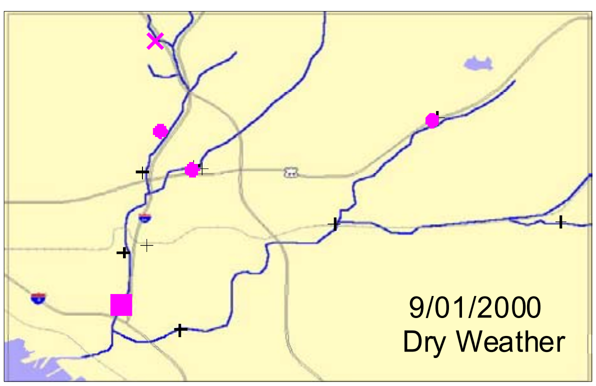
FIGURE 4.2
Hyalella azteca % Mortality
in 100% Concentration











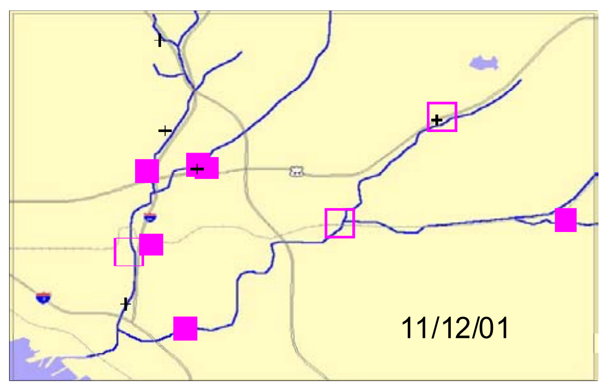
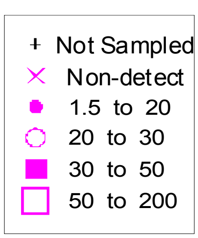
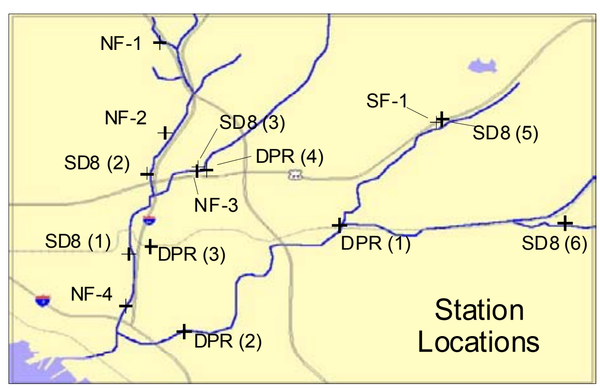


FIGURE 4.3
Total Copper
Concentrations (ug/L)





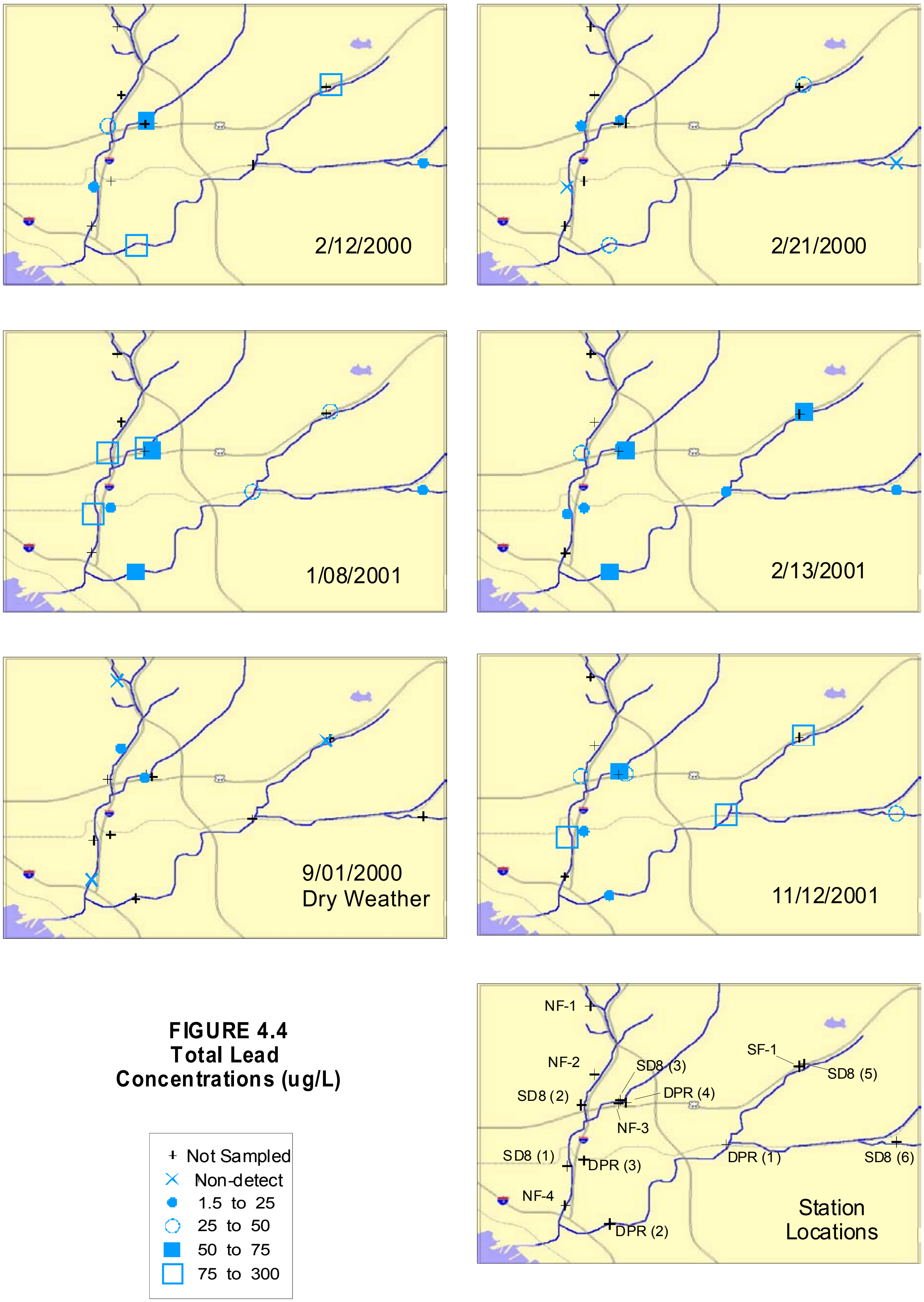


FIGURE 4.4
Total Lead
Concentrations (ug/L)

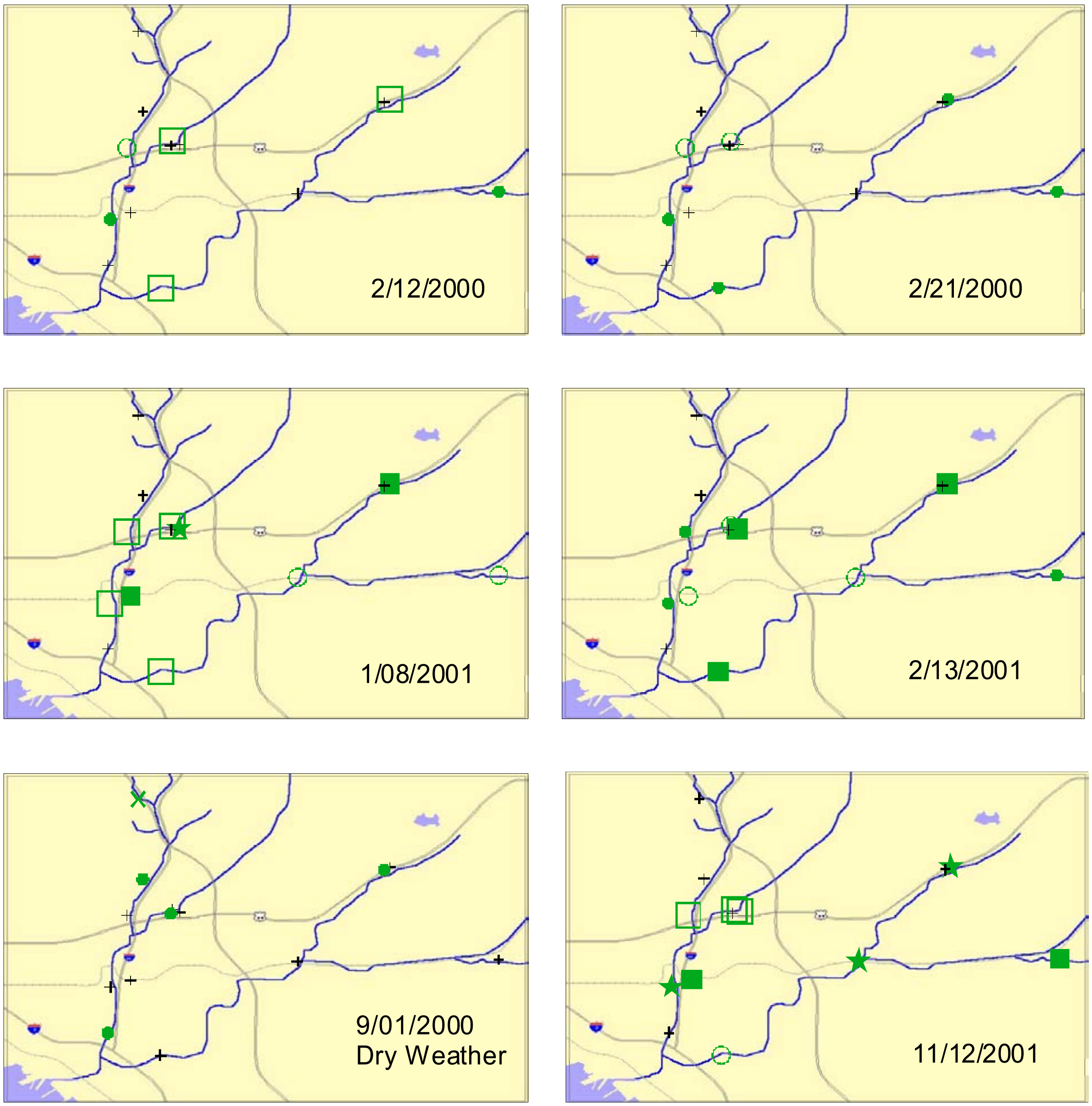
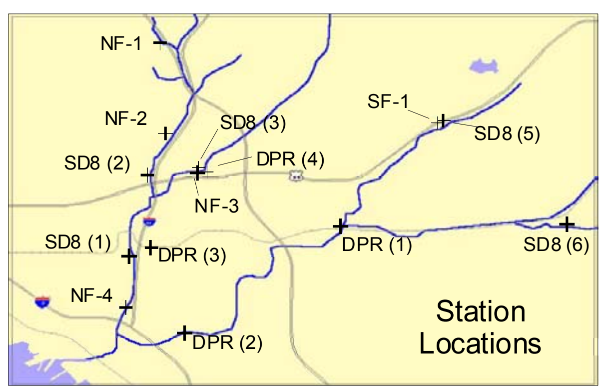
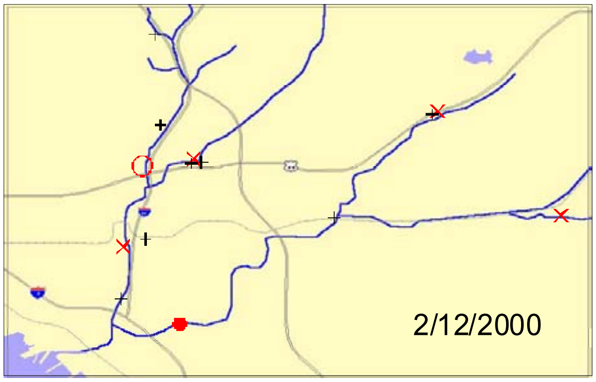
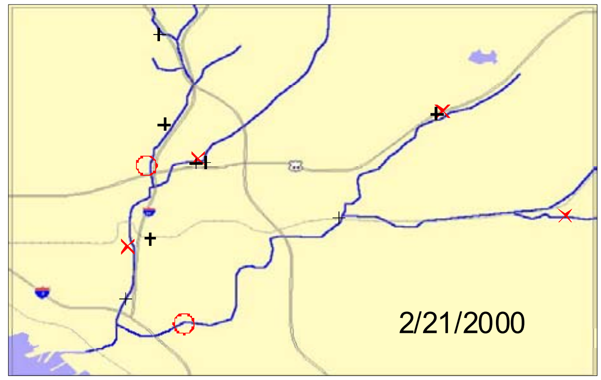


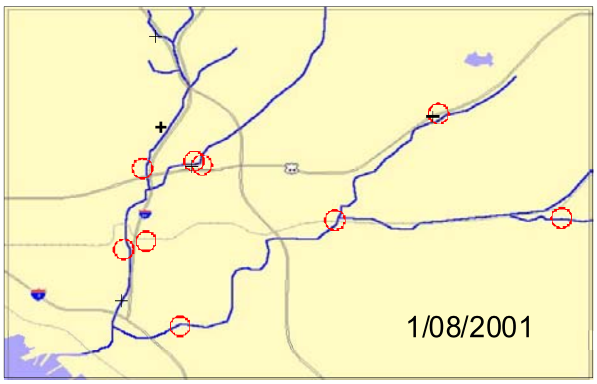
FIGURE 4.5
Total Zinc
Concentrations (ug/L)

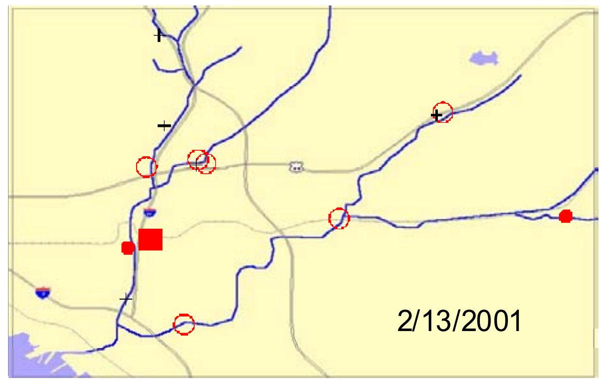
+ Not Sampled
× Non-detect
2 to 101
101 to 200
200 to 300
300 to 500
500 to 2000

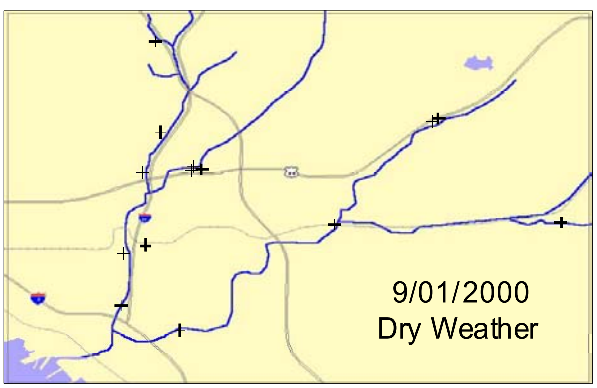


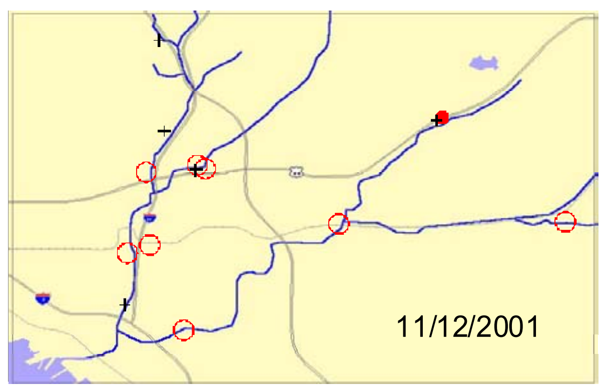












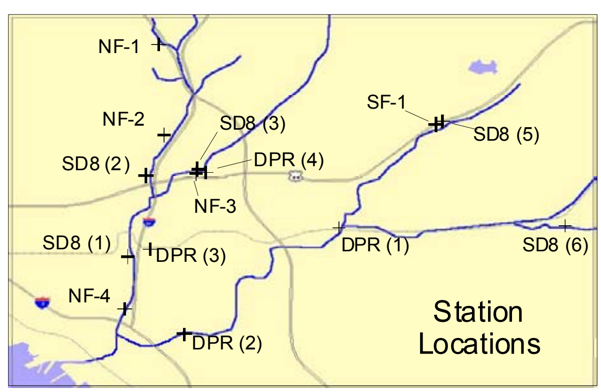


FIGURE 4.6
Dissolved Copper
Concentrations (ug/L)

+ Not Sampled
× Non-detect
● 1.5 to 5
○ 5 to 20
■ 20 to 50

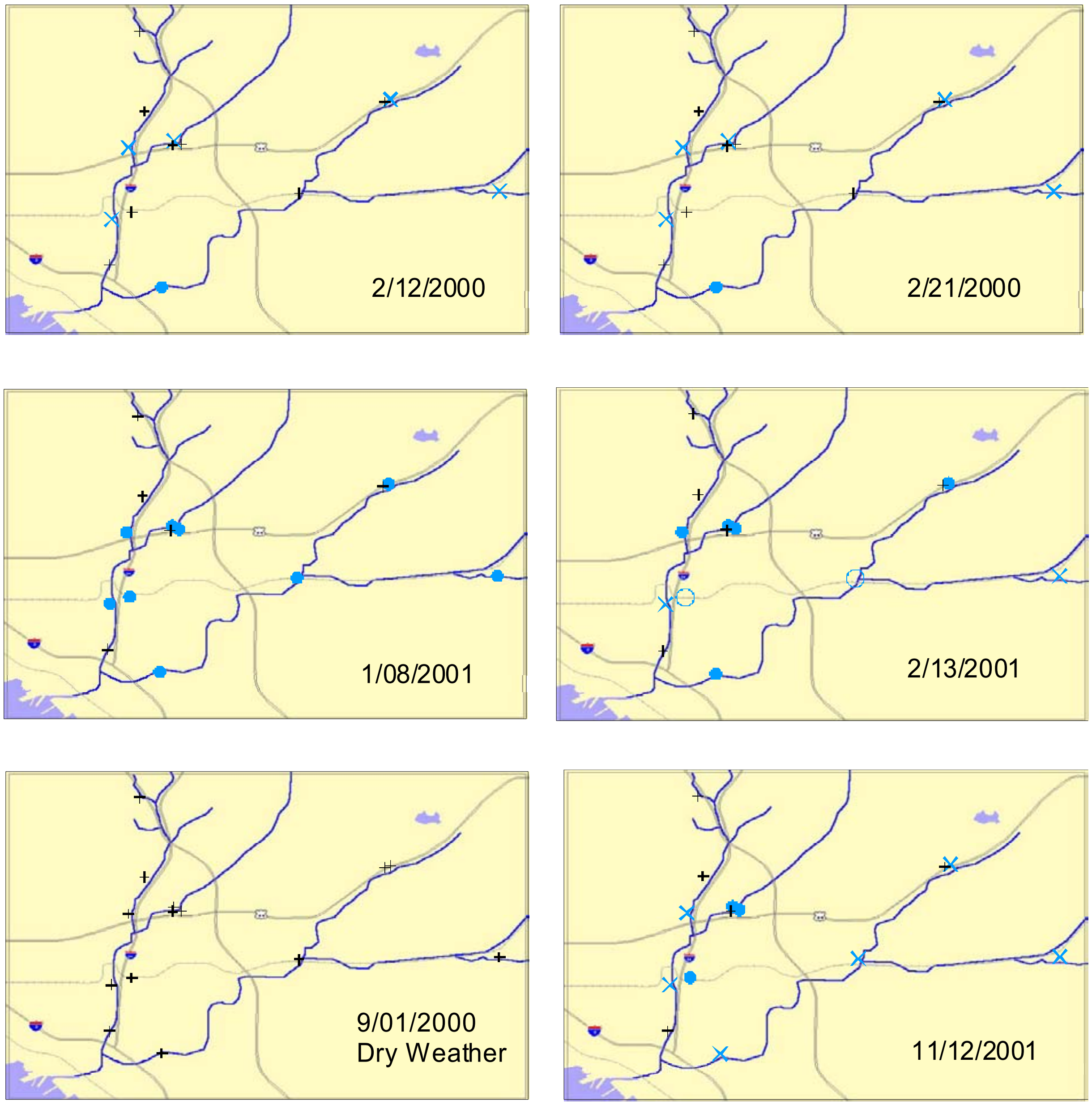
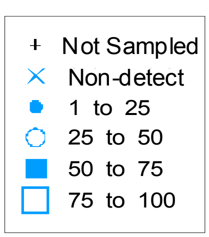
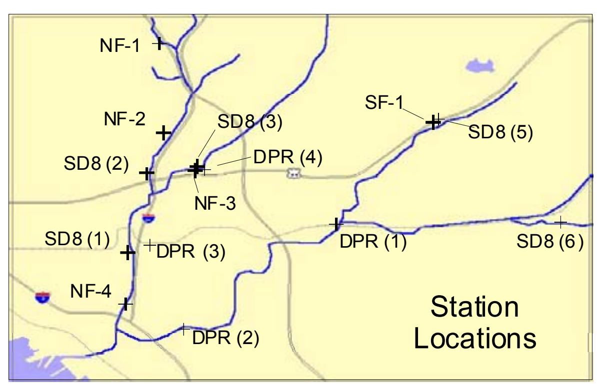


FIGURE 4.7
Dissolved Lead
Concentrations (ug/L)





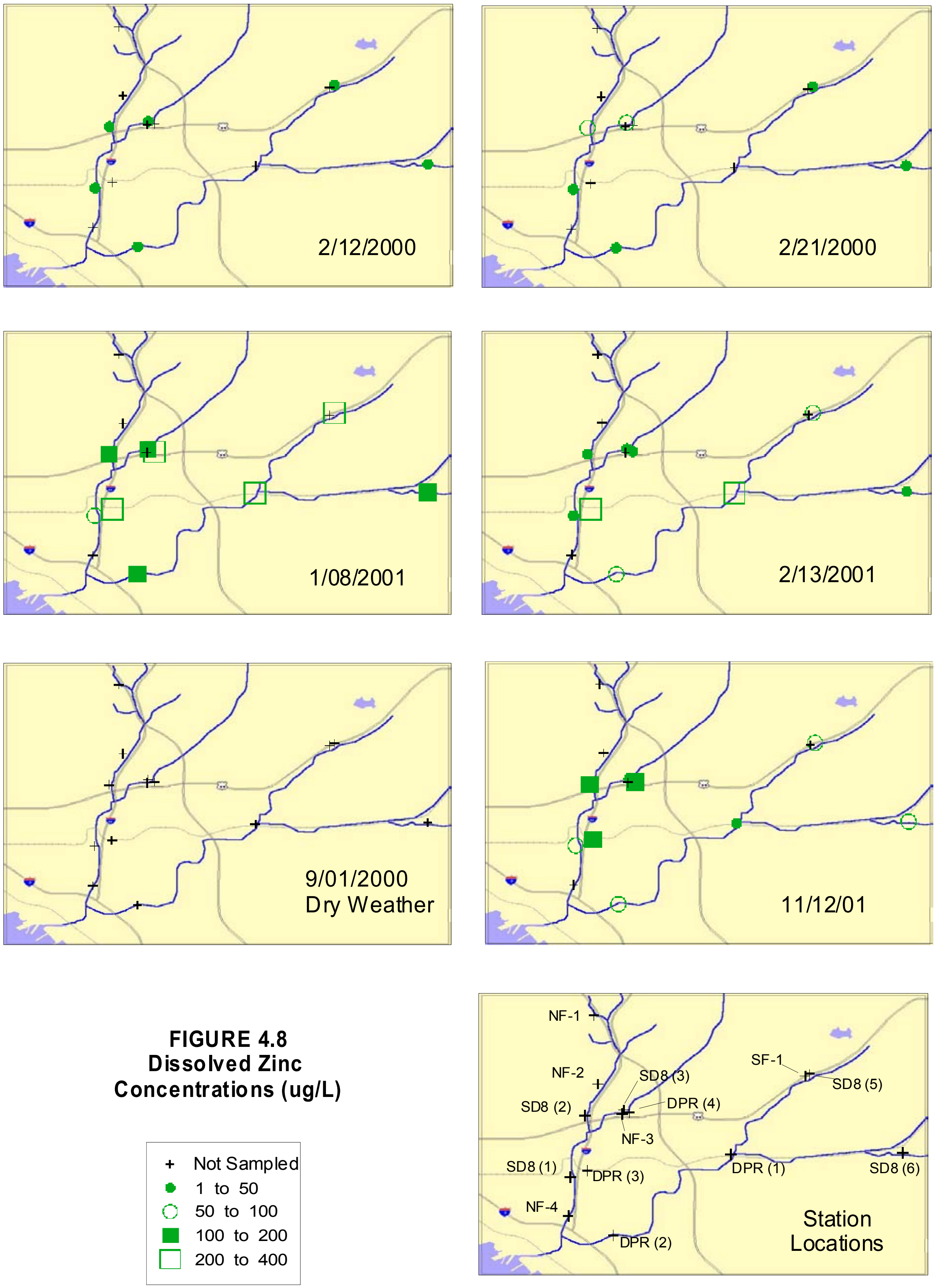


FIGURE 4.8
Dissolved Zinc
Concentrations (ug/L)

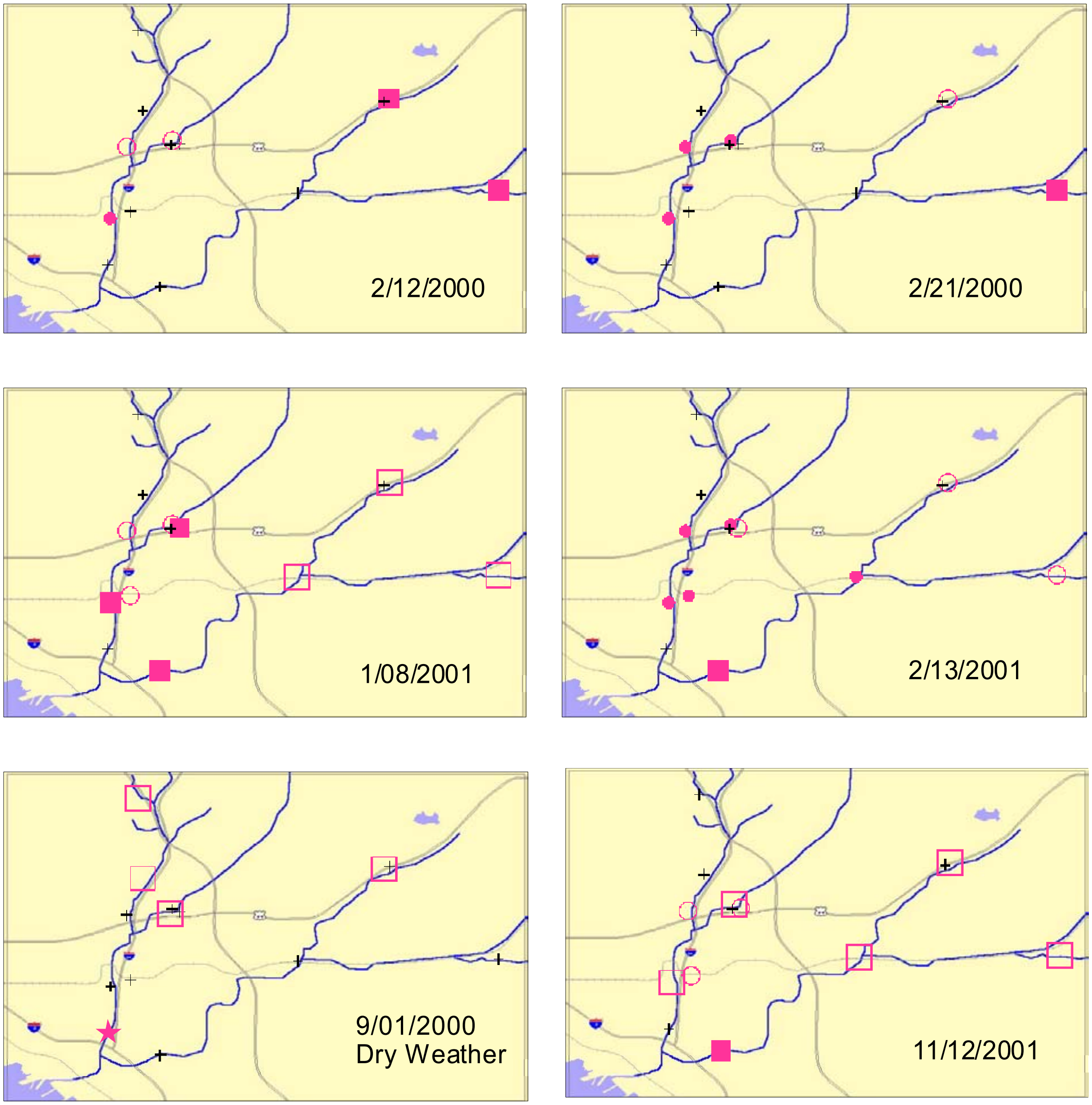
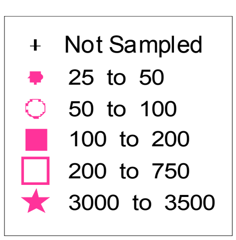
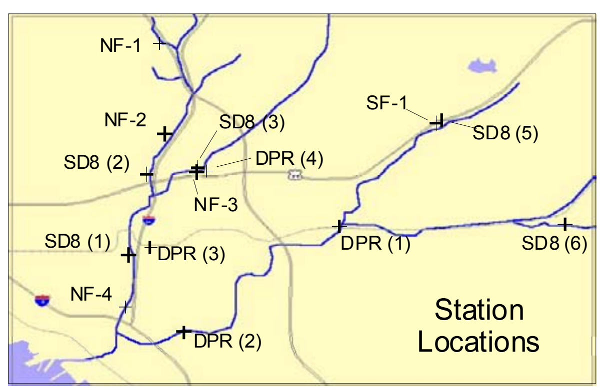


FIGURE 4.9
Hardness
Concentrations (mg/L)





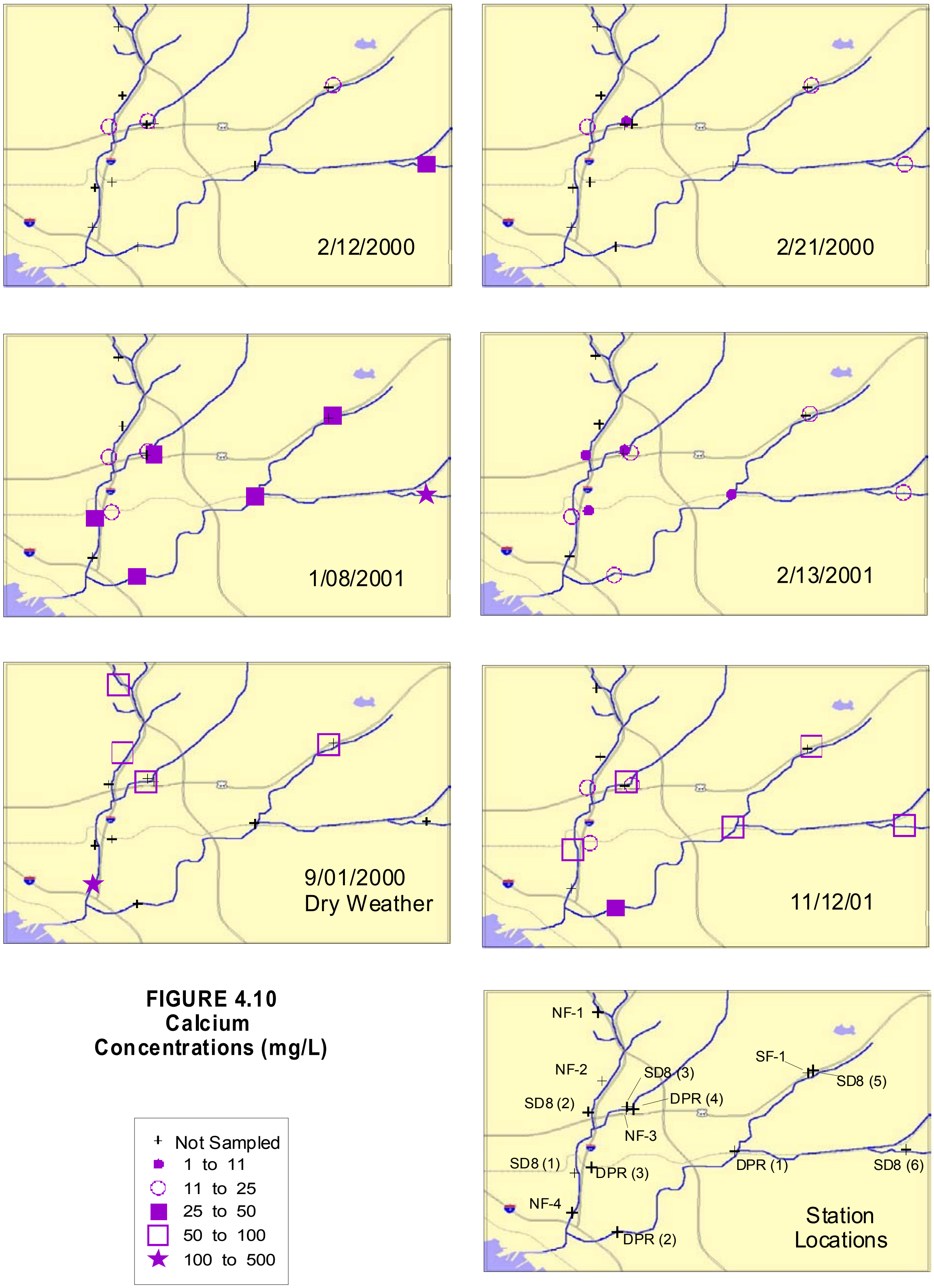
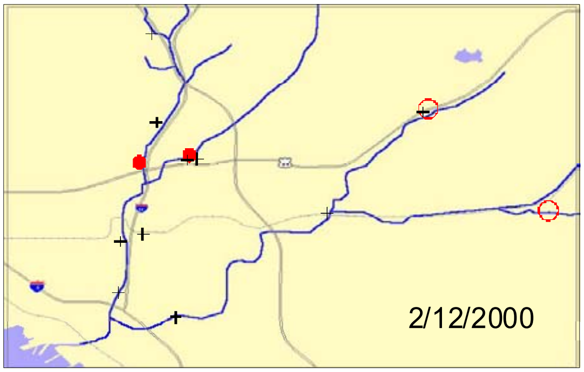
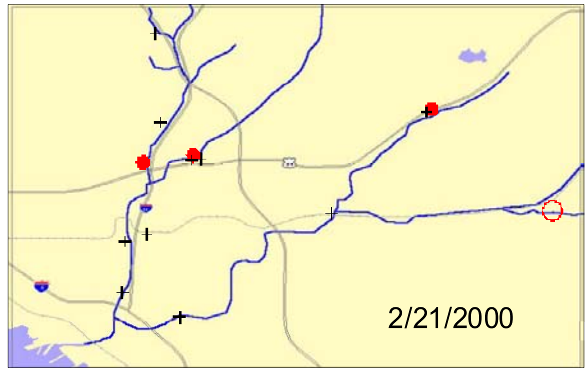
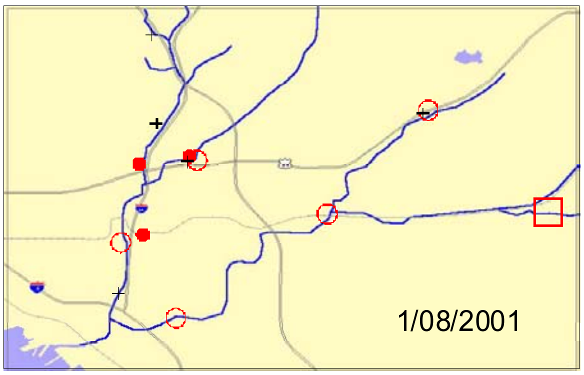
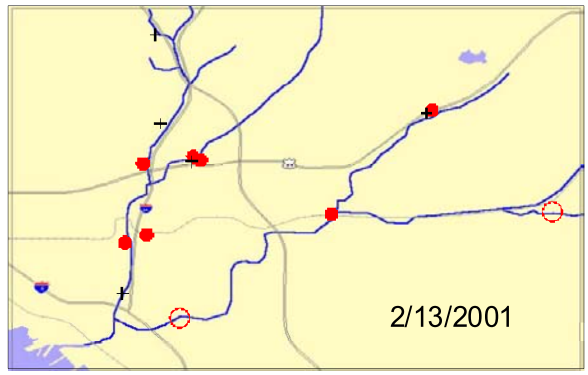


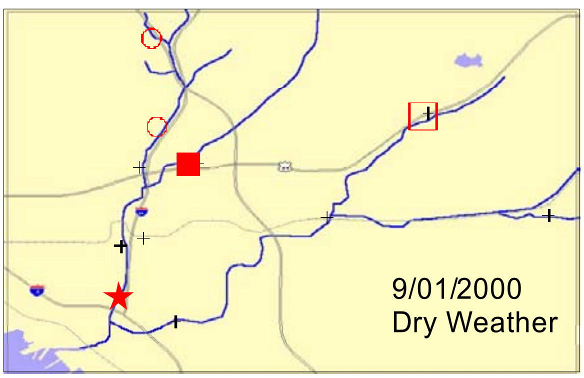
FIGURE 4.10
Calcium
Concentrations (mg/L)











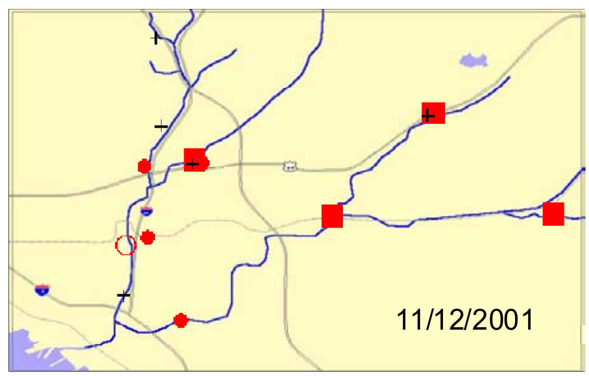
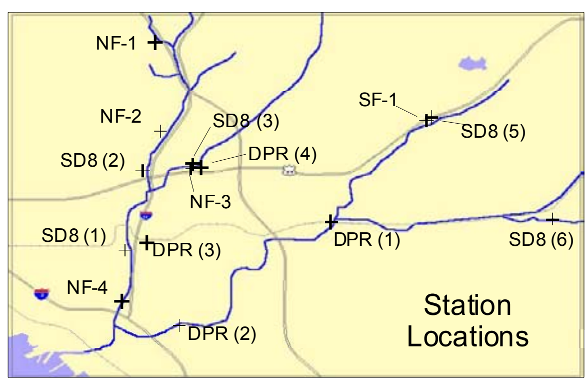


FIGURE 4.11
Magnesium
Concentrations (mg/L)



- \+ Not Sampled
- 1 to 10
- 10 to 25
- 25 to 50
- 50 to 80
- 500 to 600

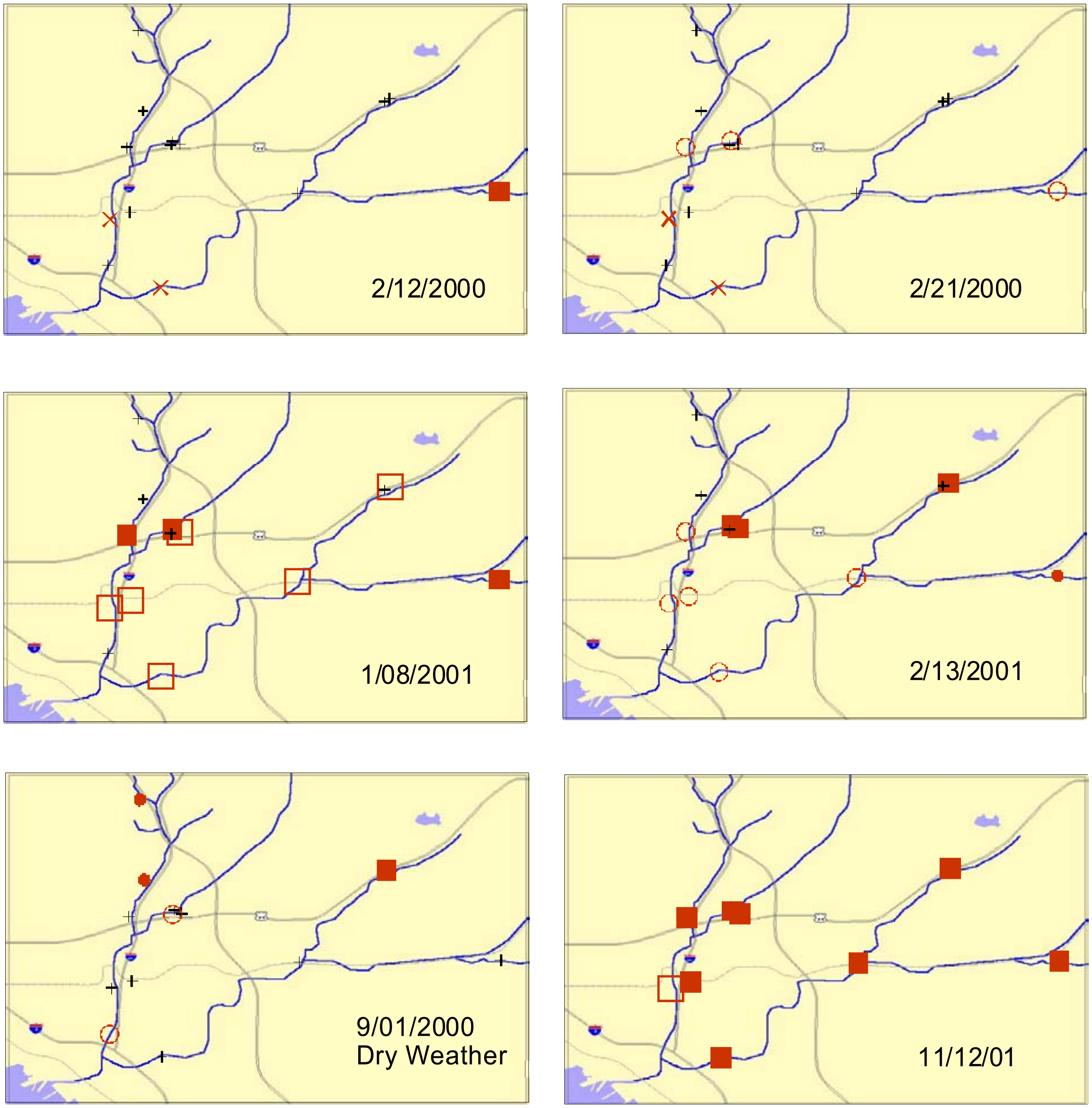
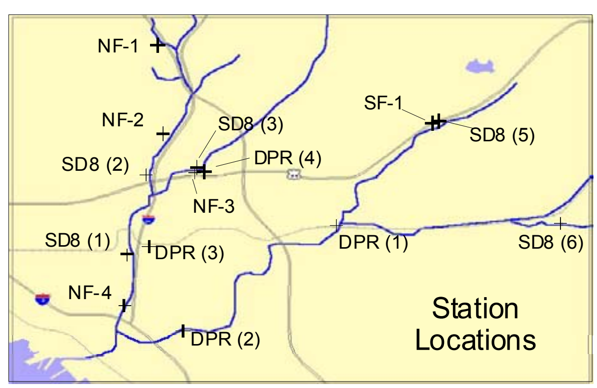


FIGURE 4.12
Chlorpyrifos
Concentrations (ppb)



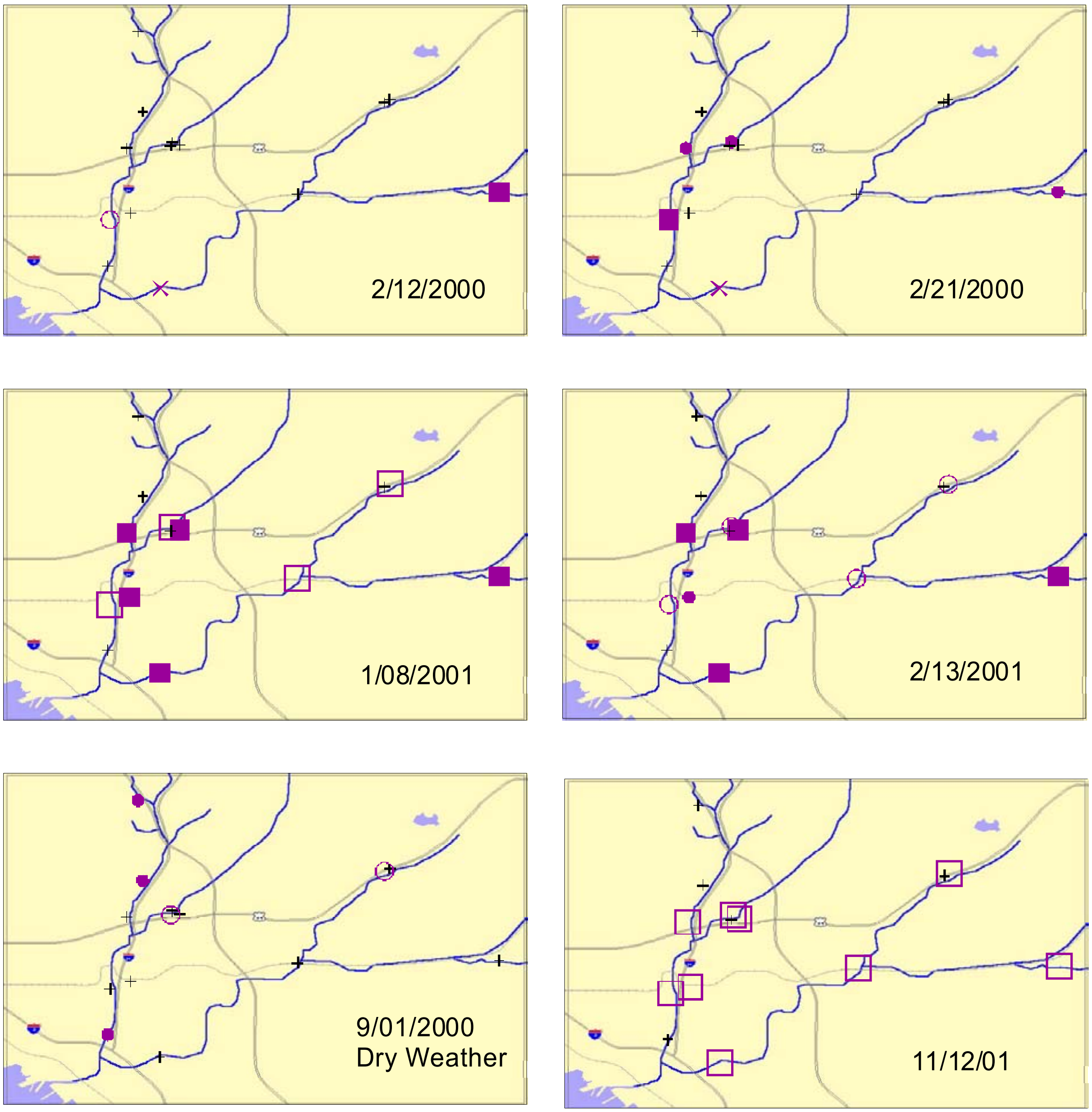


FIGURE 4.13
Diazinon
Concentrations (ppb)

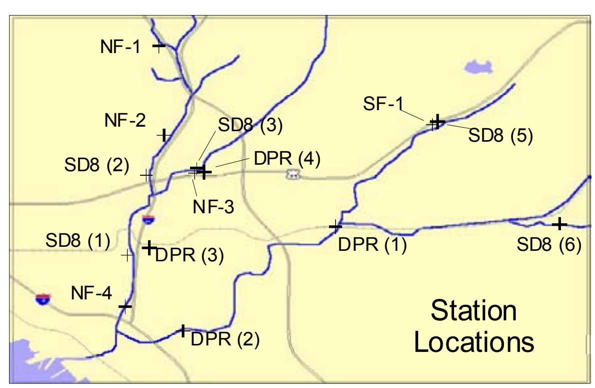


Table 4.6. Toxicity Results From All Surveys.

Station	% Survival in 100% Sample						LC_{50} (% Sample)					
	2/12/2000	2/21/2000	9/1/2000	1/8/2001	2/13/2001	11/12/2001	2/12/2000	2/21/2000	9/1/2000	1/8/2001	2/13/2001	11/12/2001
Ceriodaphnia dubia												
SD8(1)				0	100	0				59	>100	25
SD8(2)	100	100		5	100	0	>100	>100		86	>100	25
SD8(3)	65	100		0	100	0	>100	>100		59	>100	25
SD8(5)		100		0	100	90	NA	>100		81	>100	>100
SD8(6)	80	100		55	100	0	>100	>100		>100	>100	50
DPR(1)				0	100	0				59	>100	75
DPR(2)				0	55	0				87	>100	75
DPR(3)				80	95	0				>100	>100	100
DPR(4)				65	100	0				>100	>100	75
NF-1			82						>100			
NF-2			100						>100			
NF-3			98						>100			
NF-4			0						<25			
SF-1			96						>100			
Hyalella azteca												
SD8(1)				2	66	4				36	>100	33.1
SD8(2)	8	12		0	18	2	49	65		39	68	27.2
SD8(3)	4	10		26	22	0	30	34		50	52	65.4
SD8(5)		32		14	36	22		77		38	78	49
SD8(6)	34	52		28	84	16	74	>100		38	>100	49
DPR(1)				28	6	72				67	36	>100
DPR(2)				32	34	26				71	82	68.5
DPR(3)				40	88	78				85	>100	>100
DPR(4)				12	52	10				52	>100	36.8
NF-1			82						>100			
NF-2			100						>100			
NF-3			98						>100			
NF-4			96						>100			
SF-1			96						>100			

NA = not analyzed

Table 4.7. Total Metals Results From All Surveys.

Station	2/12/2000	2/21/2000	9/1/2000	1/8/2001	2/13/2001	11/12/2001	WQC
Copper (µg/L)							
SD8(1)	29	16		65	15	97	
SD8(2)	68	23		52	16	49	
SD8(3)	68	19		65	15	45	
SD8(5)	43	27		37	33	180	CMC=14
SD8(6)	23	<10		32	10	49	
DPR(1)				32	17	170	
DPR(2)	33	19		56	41	32	
DPR(3)				36	19	37	
DPR(4)				70	38	42	
NF-1			<2				
NF-2			5				
NF-3			4				
NF-4			30				
SF-1			5				CCC=9.3
Lead (µg/L)							
SD8(1)	15	<10		83	22	94	
SD8(2)	34	23		91	29	39	
SD8(3)	52	19		90	21	52	
SD8(5)	76	35		29	59	170	
SD8(6)	16	<10		19	9	36	
DPR(1)				27	23	270	CMC=82
DPR(2)	83	25.9		59	61	19	
DPR(3)				21	18	12	
DPR(4)				68	53	29	
NF-1			<2				CCC=3.2
NF-2			6				
NF-3			2				
NF-4			<2				
SF-1			<2				
Zinc (µg/L)							
SD8(1)	96	50		480	100	740	
SD8(2)	160	180		420	100	370	
SD8(3)	300	160		480	110	300	
SD8(5)	370	10		260	270	1900	
SD8(6)	100	54		160	55	290	
DPR(1)				190	120	1400	
DPR(2)	327	81		360	280	180	CMC=120
DPR(3)				230	110	200	
DPR(4)				660	280	340	
NF-1			<10				
NF-2			46				CCC=120
NF-3			5				
NF-4			20				
SF-1			12				

WQC = Water quality criteria
Colored values exceed water quality criteria, California Toxic Rule
Red shaded values exceed CMC (acute) criteria
Yellow shaded values exceed CCC (chronic) criteria

Table 4.8. Dissolved Metals Results From All Surveys.

Station	2/12/2000	2/21/2000	1/8/2001	2/13/2001	11/12/2001	WQC
			Copper (µg/L)			
SD8(1)	<5.0	<5.0	11	4	5	
SD8(2)	37	11	12	5	18	
SD8(3)	<10	<10	19	5	5	CCC=9.0
SD8(5)	<10	<10	13	5	4	
SD8(6)	<10	<10	13	3	6	
DPR(1)			13	8	6	
DPR(2)	5.3	9.6	13	5	11	
DPR(3)			17	34	19	
DPR(4)			8	5	10	
NF-1						
NF-2						
NF-3						
NF-4						
SF-1						CMC=13
			Lead (µg/L)			
SD8(1)	<1.0	<1.0	3	<1.0	<1.0	
SD8(2)	<10	<10	1	1	<1.0	
SD8(3)	<10	<10	1	2	3	CCC=2.5
SD8(5)	<10	<10	1	2	<1.0	
SD8(6)	<10	<10	1	<1.0	<1.0	
DPR(1)			1	27	<1.0	
DPR(2)	3.6	10.5	1	1	<1.0	
DPR(3)			2	46	2	
DPR(4)			1	4	2	
NF-1						
NF-2						
NF-3						
NF-4						
SF-1						CMC=65
			Zinc (µg/L)			
SD8(1)	19	28	87	32	62	
SD8(2)	45	67	160	36	130	
SD8(3)	20	57	130	36	47	
SD8(5)	45	10	290	68	73	
SD8(6)	20	30	170	33	76	
DPR(1)			200	250	40	
DPR(2)	16.8	42	180	66	55	
DPR(3)			220	370	100	
DPR(4)			230	46	110	CCC=120
NF-1						
NF-2						
NF-3						
NF-4						
SF-1						CMC=120

WQC = Water quality criteria
Colored values exceed water quality criteria, California Toxic Rule
Red shaded values exceed CMC (acute) criteria
Yellow shaded values exceed CCC (chronic) criteria

Table 4.9. General Chemistry Results From All Surveys.

Station	2/12/2000	2/21/2000	9/1/2000	1/8/2001	2/13/2001	11/12/2001
Hardness (mg/L)						
SD8(1)	40.9	35.1		170	45	200
SD8(2)	58	47		68	37	58
SD8(3)	54	36		87	40	300
SD8(5)	100	63		200	52	310
SD8(6)	120	100		640	91	280
DPR(1)				210	48	370
DPR(2)				150	110	100
DPR(3)				73	35	73
DPR(4)				160	69	72
NF-1			230			
NF-2			220			
NF-3			280			
NF-4			3200			
SF-1			520			
Magnesium (mg/L)						
SD8(1)				16	4	18
SD8(2)	6	4		5	3	5
SD8(3)	5	3		8	4	35
SD8(5)	12	7		22	6	27
SD8(6)	13	11		68	10	29
DPR(1)				20	6	36
DPR(2)				16	13	9
DPR(3)				6	4	7
DPR(4)				15	7	6
NF-1			21			
NF-2			21			
NF-3			30			
NF-4			580			
SF-1			76			
Calcium (mg/L)						
SD8(1)				42	11	51
SD8(2)	13	12		19	9	15
SD8(3)	14	10		22	10	60
SD8(5)	21	14		41	11	78
SD8(6)	26	24		140	20	64
DPR(1)				49	10	89
DPR(2)				34	20	25
DPR(3)				19	7	18
DPR(4)				40	16	19
NF-1			56			
NF-2			53			
NF-3			63			
NF-4			300			
SF-1			82			
Total Suspended Solids (mg/L)						
SD8(1)						778.6
SD8(2)						161.0
SD8(3)						1960.2
SD8(5)						2027.6
SD8(6)						226.7
DPR(1)						1490.4
DPR(2)						121.2
DPR(3)						63.9
DPR(4)						140.8

Table 4.10. Organophosphate Pesticides Results From All Surveys.

Station	2/12/2000	2/21/2000	9/1/2000	1/8/2001	2/13/2001	11/12/2001	WQC
Chlorpyrifos (ppb)							
SD8(1)	<0.5	<0.5		0.0870	0.0467	0.0972	
SD8(2)	NS	0.0433		0.0630	0.0293	0.0630	
SD8(3)	NS	0.0429		0.0743	0.0520	0.0738	
SD8(5)	NS	NS		0.0920	0.0535	0.0527	
SD8(6)	0.0717	0.034		0.0684	0.1646	0.0509	
DPR(1)				0.0820	0.0354	0.0514	
DPR(2)	<1	<1		0.0840	0.0483	0.0550	
DPR(3)				0.1103	0.0460	0.0500	
DPR(4)				0.1040	0.0611	0.0650	
NF-1			0.0133				
NF-2			0.0151				
NF-3			0.0274				
NF-4			0.0417				
SF-1			0.0790				
Diazinon (ppb)							
SD8(1)	0.27	0.35		0.7783	0.2381	1.0527	
SD8(2)	NS	0.0337		0.5312	0.3441	1.0397	
SD8(3)	NS	0.0955		0.6420	0.2051	0.6146	
SD8(5)	NS	NS		0.8086	0.2184	0.9043	
SD8(6)	0.3376	0.0509		0.5234	0.4101	1.0932	
DPR(1)				0.7899	0.2765	0.8794	
DPR(2)	<1	<1		0.5173	0.4624	1.3743	
DPR(3)				0.3709	0.0748	0.6257	
DPR(4)				0.5932	0.3221	0.622	
NF-1			0.0134				
NF-2			0.0207				
NF-3			0.1301				CCC=0.05
NF-4			0.0228				
SF-1			0.1043				CMC=0.08

NS = not sampled (either broken or not shipped to analyzing lab)
WQC = Water quality criteria
Colored values exceed water quality criteria, California Toxic Rule
Red shaded values exceed CMC (acute) criteria
Yellow shaded values exceed CCC (chronic) criteria

4.4 Comparison of Results

Toxicity
A total of five samples were collected during dry weather on September 1, 2000. With the exception of NF-4, there was little to no mortality (<20%) for both *C. dubia* and *H. azteca* during dry weather. A total of 34 samples were collected from the five different storm events for toxicity assessment to the organisms *C. dubia* and *H. azteca.* These 34 samples were collected at three locations on February 12, 2000, four locations on February 21, 2000 and nine locations on January 8, February 13, and November 12, 2001.

The toxicity to *C. dubia* observed in the storm events was quite variable from storm to storm. No single station had either consistently toxic runoff or consistently non-toxic runoff. Most notably, the samples collected in February 2000 during two different storm events did not cause considerable toxicity to *C. dubia,* with the exception of station SD8(3) with 35% mortality. Other sites for these two storms had less than or equal to 20% mortality. All samples collected on February 21, 2000 showed no toxicity to *C. dubia*. Of the three storm events sampled in 2001, the first flush sampling event of November 12 showed the highest toxicity, with the exception of station SD8(5). During this storm runoff collected at SD8(5) caused 10% mortality, whereas storm water from all other stations caused 100% mortality to *C. dubia*. The storm event of January 8 showed 100% mortality from runoff at five of the nine sites. No trends within watershed reaches, either upstream vs. downstream or north vs. south, were observable for *C. dubia* mortality (Figure 4.1)

The toxicity of stormwater to *H. azteca* was less variable from storm to storm than to C. dubia. Toxicity was observed in each storm event. The first flush storm event of November 12, 2001 did not show higher mortality to *H. azteca*. There is no evidence the fire that may have impacted the January 8 samples had any influence on *H. azteca* mortality. No trends within the watershed reaches, either upstream vs. downstream or north vs. south, were observable for *H. azteca* (Figure 4.2).

Total Metals
Total metals concentrations were higher during storm events than during the dry weather sampling. The dry sampling site furthest upstream (NF-1) had non-detect values for all three metals parameters. The highest concentrations of metals were detected in the first flush storm event of November 12, 2001. The storm event of January 8, 2001 were the next highest concentrations measured.

Table 4.11 below lists average concentrations of total metals from each event. Sample results that were non-detect were treated as one-half the value of the detection limit.

Table 4.11. Mean concentration of total metals (µg/L) in the watershed for each storm event

Event Date	2/12/2000	2/21/2000	1/8/2001	2/13/2001	11/12/2001
T. Copper	44	18	49	23	78
T. Lead	46	19	54	33	80
T. Zinc	226	89	349	158	636

Concentrations of copper at all sites exceeded California Toxic Rule water quality criteria during all storm events and were high throughout the watershed (Figure 4.3). Concentrations of lead exceeded California Toxic Rule acute water quality criteria during all storm events (Figure 4.4). Total zinc concentrations exceeded the California Toxic Rule water quality criteria at several locations during each storm event (Figure 4.5). No trends were observable for any of the total metals within the watershed reaches, either upstream vs. downstream or north vs. south fork.

Dissolved Metals

Dissolved metals were not analyzed for the dry weather event because the samples were placed into sample containers pre-preserved with nitric acid. Dissolved metals were analyzed by different laboratories for the 1999-2000 samples and each laboratory had different reporting limits. Some reporting limits were higher than water quality criteria. Therefore, some results may be characterized as not detected and have concentrations in the samples that exceed water quality criteria.

Dissolved copper concentrations were highest in the January 8, 2001 storm event (Figure 4.6) Concentrations of dissolved lead did not exceed California Toxic Rule acute water quality criteria for any stations at any storm. Dissolved zinc concentrations exceeded the California Toxic Rule water quality criteria at all but one location during the January 8, 2001 storm event and at several locations during the February 13 and November 12, 2001 storm events. No trends were observable for any of the dissolved metals within the watershed reaches, either upstream vs. downstream or north vs. south fork.

Table 4.12. Mean concentration of dissolved metals (μg/L) in the watershed for each storm event

Event Date	2/12/2000	2/21/2000	1/8/2001	2/13/2001	11/12/2001
Copper	10	6	13	8	9
Lead	4	5	1	9	1
Zinc	28	39	185	104	77

General Chemistry

Hardness, calcium, and magnesium concentrations were higher in the dry-weather sampling event than in the storm events. Station NF-4 had concentrations of an entire magnitude higher than all other sampling. This station was considered as an outlier in the regression plots with mortality. The prevalent trend indicated a dilution of these analytes as stormwater runoff flushed the area. During wet weather sampling, the levels of these parameters were higher in upstream sites. In accordance with this, site SD8(6) generally had higher levels of hardness, calcium, and magnesium relative to the sampling event. Another overall trend indicated the south fork generally had higher levels relative to each event than the north fork.

As with other analytes, samples collected in the January 8 and the November 12, 2001 storm events had relatively higher hardness. Hardness itself was higher in the south fork especially at upstream sites, SD8(5) and SD8(6) (Figure 4.9).

Calcium was also higher in the south fork during all storms (Figure 4.10). SD8(6) had extremely high levels during the January 8 event.

Magnesium concentrations were greater in the south fork (Figure 4.11).

Organophosphate Pesticides

Data collected in prior events may not provide an accurate description of trends for the pesticides diazinon and chlorpyrifos. Stations DPR(2) and SD8(1) had different detection limits than the other sites (1.0 and 0.5 μg/L respectively). These detection limits were higher than any value detected at other sites.

Chlorpyrifos levels were highest during the January 8 and November 12, 2001 storms.

Diazinon concentrations exceeded water quality standards for all events at all sites except SD8(2) on February 21, 2001. Diazinon concentrations were greatest during the November 12, 2001 storm.

No trends were observable for diazinon or chlorpyrifos with the watershed reaches either upstream vs. downstream or north vs. south fork.

4.5 Statistical Data Analyses

To assess contaminant source by area, the data was converted to numerical rank based upon water quality standards. Total metals rankings were grouped by creek fork. The numerical values used to set the ranks were the numeric targets used by the Regional Water Quality Control Board in the TMDL. For metals the numeric targets established using the California Toxics Rule were utilized to set the rank values and for diazinon the numeric targets established in by the water quality criterion developed by California Department of Fish and Game were utilized. No numeric target has been set by the RWQCB for chlorpyrifos, so the diazinon numeric target was also applied to this organophosphate pesticide. This numerical rankings were organized by reach. SD8(2) and from the NF(2) were grouped together as they represent samples east tributary of the north branch of the creek. SD8(3) and DPR(4) represent a sample from the west tributary of the north branch. SD8(1) and DPR(3) represent that part of the north branch downstream and after the confluence of the east and west tributaries of the north branch. SD8(5) represents the west tributary of the south branch of the creek. SD8(6) represents the east branch of the creek. DPR(2) and DPR(1) represent that part of the south branch downstream and after the confluence of the east and west tributaries. Mean rank by reach was calculated to identify high contaminant areas vs. low contaminant areas. This information is presented in Table 4.13.

Ranked data was assessed by tributary reach to provide an indication of source identification for further source study. Based upon the ranking evaluation, the following was observed.

- Chlorpyrifos concentrations are greater in the west tributary of the south fork of Chollas Creek and in the downstream reaches of the south fork of Chollas Creek.

- Diazinon and total copper concentrations are high throughout all of Chollas Creek. Total lead concentrations are present at mid-levels (based upon rankings) throughout the watershed.

- Total zinc concentration rankings do not include data from January 8, 2001 because concentrations during that event for zinc exceed the historical range of concentrations found since the 1993-1994 storm water monitoring in Chollas Creek and may have been influenced by the Viejas fire. Total zinc concentrations are low in the downstream reaches of the north fork of Chollas Creek, downstream of east and west tributaries. Total zinc concentrations are higher in both the east and west tributaries of the north fork of the Creek. Total zinc concentrations are high in the lower reaches of the south fork of Chollas Creek; however, the east tributary of this fork of Chollas Creek contributes low concentrations of total zinc while the western tributary of this fork contributes higher concentrations of total zinc.

- Dissolved lead and dissolved zinc concentrations are low throughout all of Chollas Creek.

- Dissolved copper concentrations are high in the east tributary of the north fork of Chollas Creek and low in all other areas.

Table 4.13. Ranked Concentrations for Cholas Creek DPR Study.

		NORTH FORK						SOUTH FORK				
DATE	ANALYTE	North Fork Downstream of East and West Tributaries		North Fork- East Tributary		North Fork -West Tributary		South Fork Downstream of the East and West Tributaries		South Fork - West Tributary	South Fork - East Tributary	RANK LIMITS
		SD8(1)	DPR(3)	SD8(2)	NF-2	SD8(3)	DPR(4)	DPR(2)	DPR(1)	SD8(5)	SD8(6)	
2/12/2000	Chlorpyrifos	1						3			2	3 ≥ 0.08
2/21/2000	Chlorpyrifos	3		1		1		3			1	2 ≥ 0.05
1/8/2001	Chlorpyrifos	3	3	2		2		2	3	3	3	1 > DL
2/13/2001	Chlorpyrifos	1	1	1		2	2	1	1	2	1	0 = ND
11/12/2001	Chlorpyrifos	3	2	2		2	2	2	2	2	2	
	Mean	1.8		1.5		1.8		2.1		2.3	1.8	
2/12/2000	Diazinon	3						3			3	3 ≥ 0.08
2/21/2000	Diazinon	3		1		3		3			2	2 ≥ 0.05
1/8/2001	Diazinon	3	3	3		3	3	3	3	3	3	1 > DL
2/13/2001	Diazinon	3	2	3		3	3	3	3	3	3	0 = ND
11/12/2001	Diazinon	3	2	3		2	2	3	3	3	3	
	Mean	2.8		2.5		2.4		3.0		3.0	2.8	
2/12/2000	Copper	3		3		3		3		3	3	3 ≥ 14
2/21/2000	Copper	3		3		3		3		3	2	2 ≥ 9.3
1/8/2001	Copper	3	3	3		3	3	3	3	3	3	1 > DL
2/13/2001	Copper	3	3	3		3	3	3	3	3	2	0 = ND
11/12/2001	Copper	3	3	3		3	3	3	3	3	3	
	Mean	3.0		3.0		3.0		3.0		3.0	2.6	
2/12/2000	Lead	2		2		2		3		2	2	3 ≥ 82
2/21/2000	Lead	1		2		2		2		2	2	2 ≥ 3.2
1/8/2001	Lead	3	2	3		3	2	2	2	2	2	1 > DL
2/13/2001	Lead	2	2	2		2	2	2	2	2	2	0 = ND
11/12/2001	Lead	3	2	2		2	2	2	3	3	2	
	Mean	2.0		2.3		2.2		2.2		2.2	2.0	
2/12/2000	Zinc	1		3		3		3		3	1	3 ≥ 120
2/21/2000	Zinc	1		3		3		1		1	1	
2/13/2001	Zinc	1	1	1		1	3	3	3	3	1	1 > DL
11/12/2001	Zinc	3	3	3		3	3	3	3	3	3	0 = ND
	Mean	1.7		2.4		2.6		2.6		2.5	1.5	

Table 4.13. Continued.

DATE	ANALYTE	NORTH FORK						SOUTH FORK				RANK LIMITS
		North Fork Downstream of East and West Tributaries		North Fork- East Tributary		North Fork -West Tributary		South Fork Downstream of the East and West Tributaries		South Fork - West Tributary	South Fork - East Tributary	
		SD8(1)	DPR(3)	SD8(2)	NF-2	SD8(3)	DPR(4)	DPR(2)	DPR(1)	SD8(5)	SD8(6)	
2/12/2000	Dissolved Copper	0		3		0*		1		0*	0*	3 ≥ 13
2/21/2000	Dissolved Copper	0		2		0*		2		0*	0*	2 ≥ 9.0
1/8/2001	Dissolved Copper	2	3	2		3	1	3	3	3	3	1 > DL
2/13/2001	Dissolved Copper	1	3	1		1	1	1	1	1	1	0 = ND
11/12/2001	Dissolved Copper	1	3	3		1	2	2	1	1	1	
	Mean	1.6		2.2		1.1		1.8		1.0	1.0	
2/12/2000	Dissolved Lead	0		0*		0*		2		0*	0*	3 ≥ 65
2/21/2000	Dissolved Lead	0		0*		0*		2		0*	0*	2 ≥ 2.5
1/8/2001	Dissolved Lead	2	1	1		1	1	1	1	1	1	1 > DL
2/13/2001	Dissolved Lead	0	2	1		1	2	1	2	1	0	0 = ND
11/12/2001	Dissolved Lead	0	1	0		2	1	0	0	0	0	
	Mean	0.75		0.4		1.0		1.1		0.4	0.2	
2/12/2000	Dissolved Zinc	1		1		1		1		1	1	3 ≥ 120
2/21/2000	Dissolved Zinc	1		1		1		1		1	1	
2/13/2001	Dissolved Zinc	1	3	1		1	1	1	3	1	1	1 > DL
11/12/2001	Dissolved Zinc	1	1	3		1	1	1	1	1	1	0 = ND
	Mean	1.0		1.5		1.0		1.3		1.0	1.0	

Note: Zinc concentrations for 1/8/01 (fire impacted event) were not included in this ranking because concentrations of zinc exceeded historical ranges for Chollas Creek.
* Detection limit exceeds water quality criteria.

A regression analysis was performed to provide an indication of toxicity correlation to chemical contaminant. This information is presented in Table 4.14. The regression analysis was performed on all wet weather data. Dry-weather data was excluded from this analysis.

Table 4.14. Mortality Regression for Target Analytes.

Hyalella			*Ceriodaphnia*		
Analyte	Prob >F	r^2	Analyte	Prob >F	r^2
Chlorpyrifos	**0.0466**	0.1297	Chlorpyrifos	**0.0137**	0.1920
Diazinon	0.1148	0.0835	Diazinon	**0.0001**	0.7032
Hardness	0.7968	0.0021	Hardness	**0.0124**	0.1801
Calcium	0.7766	0.0026	Calcium	**0.0074**	0.2038
Magnesium	0.8389	0.0013	Magnesium	**0.0243**	0.1486
Copper	0.5622	0.0106	Copper	**0.0027**	0.2490
Lead	0.9576	0.0001	Lead	**0.0145**	0.1728
Zinc	0.7018	0.0046	Zinc	**0.0058**	0.2147
Dis Copper	0.5912	0.0091	Dis Copper	0.6836	0.0053
Dis Lead	0.1501	0.0636	Dis Lead	0.0576	0.1081
Dis Zinc	0.8460	0.0012	Dis Zinc	0.3480	0.0276
TSS	0.8999	0.0024	TSS	0.1115	0.3213

The regression analysis showed a correlation between *C. dubia* mortality and diazinon (r^2 = 0.7032). A statistically significant, but not strong, correlation was also observed between *C. dubia* mortality and chlorpyrifos, hardness, calcium, magnesium, copper, lead, and zinc. The regression analysis performed on *H. azteca* vs. chemistry demonstrated a statistically significant, but not strong relationship between *H. azteca* mortality and chlorpyrifos. Total suspended solids only included nine observations (samples collected in the first flush event of November 12, 2001).

Total suspended solids was added to the analyte list following the February 13, 2001 storm event because correlation between chemistry and toxicity was not strong based upon the data collected up to that time (n=25). The statistically significant but not strong correlation of total metals to toxicity is curious as the biologically available forms of metals are the dissolved forms. This confounding issue and was considered potentially related to suspended solids load in the sample. The addition of nine total suspended solids measures did not clarify this issue. Further, after the most recent event of November 12, 2001 and the additional samples, a good correlation between toxicity to C. dubia and diazinon is apparent. The statistically significance of total metals in the regression analysis with diazinon does not provide a strong correlation. The best correlation was r^2=0.2490 for copper. The diazinon appears to be the cause of the toxicity to this organism. This confirms the TIE testing coordinated and reported by SCCWRP (SCCWRP 1999).

C. dubia mortality vs. copper and diazinon concentrations are plotted on Figure 4.14. A relationship between diazinon and copper concentrations to *C. dubia* mortality was observed. This plot indicates a relationship of greater than 20% mortality when concentrations of diazinon are greater than 0.4 µg/L and copper concentrations are greater than 40 µg/L (with the exception of one outlier point). Additional research would be required to confirm this relationship and the associated concentration thresholds.

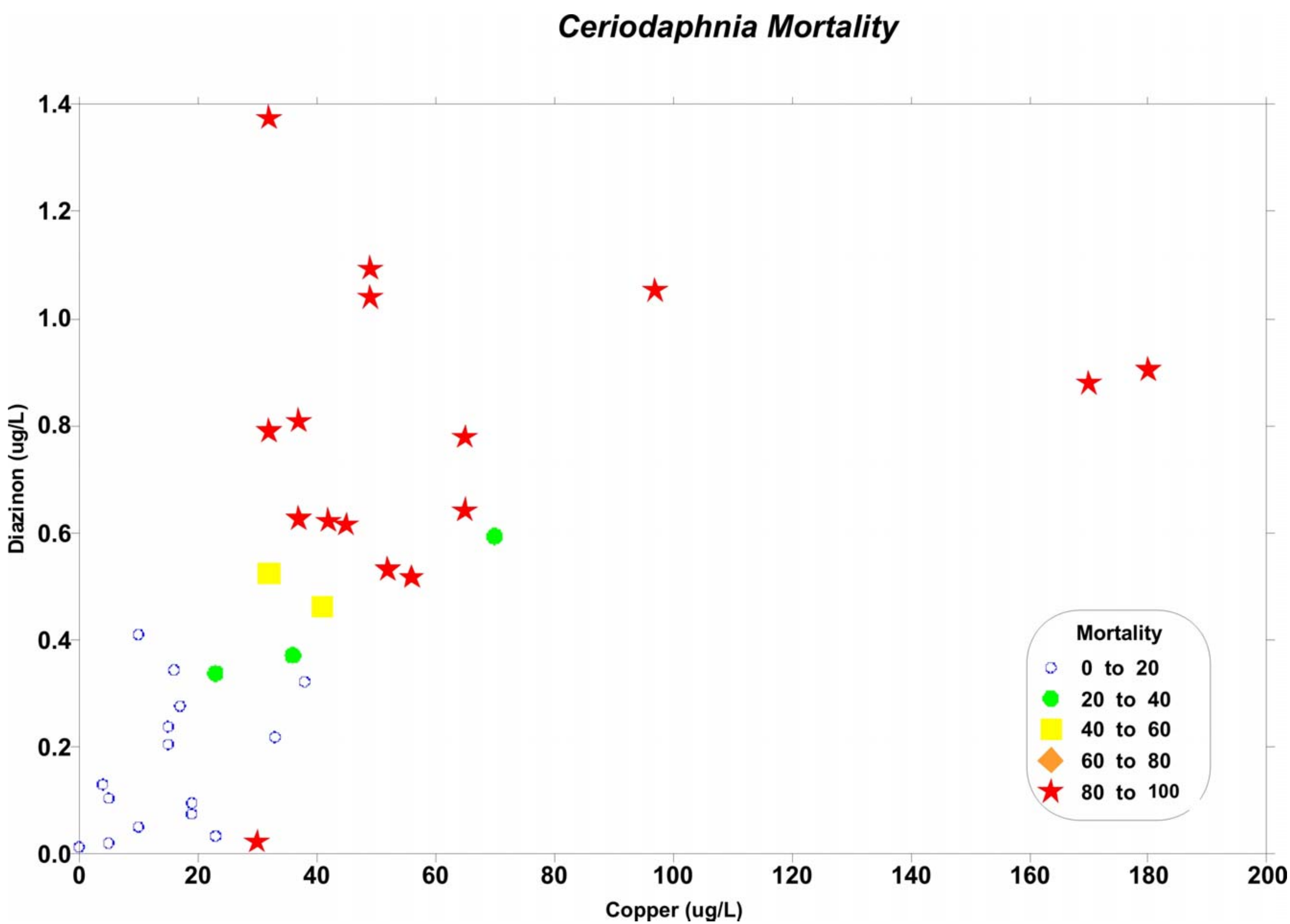


Figure 4.14. Relationship Between Diazinon and Copper Concentrations and *Ceriodaphnia* Mortality.

4.6 Mass Loading Estimates

An estimation of mass load for each of the following contaminants, total lead, total copper, total zinc, diazinon, and chlorpyrifos were calculated for the two storm events conducted in the 2000-2001 wet-weather sampling period. The following lists mass estimates (total grams) of each contaminant by station for each date.

Station	g Cu	g Pb	g Zn	g Diazinon	g Chlorpyrifos
January 8, 2001					
SD8(1)	1145	1462	8453	13.71	1.53
SD8(2)	568	994	4586	5.80	0.69
SD8(3)	267	369	1971	2.64	0.31
SD8(5)	141	110	988	3.07	0.35
SD8(6)	52	31	260	0.85	0.11
DPR(1)	2006	1693	11911	49.52	5.14
DPR(2)	4266	4494	27424	39.41	6.40
DPR(3)	139	81	887	1.43	0.43
DPR(4)	87	85	825	0.74	0.13
February 13, 2001					
SD8(1)	2941	4313	19604	46.68	9.16
SD8(2)	332	603	2078	7.15	0.61
SD8(3)	51	71	372	0.69	0.18
SD8(5)	41	74	337	0.27	0.07
SD8(6)	80	72	438	3.27	0.13
DPR(1)	1736	2349	12256	28.24	3.62
DPR(2)	10602	15774	72407	119.57	12.49
DPR(3)	343	325	1988	1.35	0.83
DPR(4)	4041	5636	29773	34.25	6.50
November 12, 2001					
SD8(1)	2678	2596	20434	29.07	2.68
SD8(2)	577	459	4357	12.24	0.74
SD8(3)	242	280	1616	3.31	0.40
SD8(5)	4074	3847	42999	20.47	1.19
SD8(6)	90	66	531	2.00	0.09
DPR(1)	754	1198	6212	3.90	0.23
DPR(2)	283	168	1594	12.17	0.49
DPR(3)	185	60	1000	3.13	0.27
DPR(4)	69	48	560	1.02	0.11

Section 5: Results Summary

Chollas Creek is an urban watershed and the contamination measured was ubiquitous throughout the watershed in storm events. Metals, diazinon and chlorpyrifos were detected in all reaches of the watershed at varying concentrations in each storm event. No single station or reach of the Creek was identified as the contributor of contaminants. Diazinon is linked to toxicity to *C. dubia* in the storm water samples, however toxicity of storms to *C. dubia* varied widely from storm to storm. Storm water was consistently toxic to *H. azteca*, however no strong correlation between this toxicity and any analyte tested was observed in this study.

- Each storm event sampled varied by toxicity to test species and concentrations of contaminants measured. Storm water toxicity to *C. dubia* was more variable from storm to storm than toxicity to *H. azteca*.

- Concentrations of contaminant and toxicity varied at each sampling station varied from storm to storm without a consistent pattern in the watershed.

- A correlation between toxicity to *C. dubia* and diazinon was observed for this study after collecting the fifth storm event. It took a total of 34 samples to obtain this correlation r^2 = 0.7032.

- The first flush storm of the season had the highest toxicity effects throughout the watershed at each station and the highest concentrations of diazinon detected at all stations. The mean concentrations of total metals for all stations was highest during the first flush storm event, however the mean concentrations of dissolved metals was not considerably greater during the first flush event than other storms monitored. Concentrations of chlorpyrifos during the first flush storm were within the range of concentrations observed during each storm event.

Clear contributions of contaminant source were not observable through the data maps presented in Figures 4.1 through 4.13. Therefore the numerical ranking analysis as described in Section 4.5 was conducted to identify any trends. These observations were made based upon a limited data set.

- Chlorpyrifos concentrations are greater in the west tributary of the south fork of Chollas Creek and in the downstream reach of the south fork of Chollas Creek.

- Diazinon and total copper concentrations are high (exceed chronic water quality criteria during the majority of the storm events) throughout all of Chollas Creek.

- Total lead concentrations are at mid-levels (exceed acute water quality criteria during the majority of the storm events) throughout all of Chollas Creek.

- Total zinc concentrations are low (do not exceed water quality criteria during the majority of the storm events) in the lower reaches of the north fork of Chollas Creek, downstream of east and west tributaries. This may be due to a dilution effect as water reaches this location, because upstream in both the east and west tributaries of the north fork, total zinc concentrations are higher (exceed chronic water quality criteria during many of the storm events). Total zinc concentrations are high in the lower reaches of the south fork of the creek; however the east tributary contributes low concentrations of total zinc while the western tributary contributes higher concentrations of total zinc.

- Dissolved metals concentrations were low throughout all of Chollas Creek with the exception of dissolved copper concentrations in the east tributary of the north fork of Chollas Creek, which had dissolved copper levels in exceedance of the acute water quality criteria for all but one storm event.

- A relationship between diazinon and copper concentrations to *C. dubia* mortality was observed. The data indicates a relationship of greater than 20% mortality when concentrations of diazinon are greater than 0.4 µg/L and copper concentrations are greater than 40 µg/L (with the exception of one outlier point). Additional research would be required to confirm this relationship and the associated concentration thresholds.

Section 6: References

Kinnetic Laboratories Incorporated (1994), 1993-1994 City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program.

Kinnetic Laboratories Incorporated (1995), City of San Diego and Co-Permittee Stormwater Monitoring Program 1994-1995.

SCCWRP (1999), TIE Study in Chollas Creek.

SDRWQCB (1999), www.swrb.ca.gov/rwqcb.9/Programs/TMDL/tmdl.html.

URS (2000b), Chollas Creek Water Quality Sampling 2000-2001 Season- First Sampling Event, October 17, 2000.

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URS (1999), 1998-1999 City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report.

URS (2000a), 1999-2000 City of San Diego and Co-Permittee NPDES Stormwater Monitoring Report, August 10, 2000.

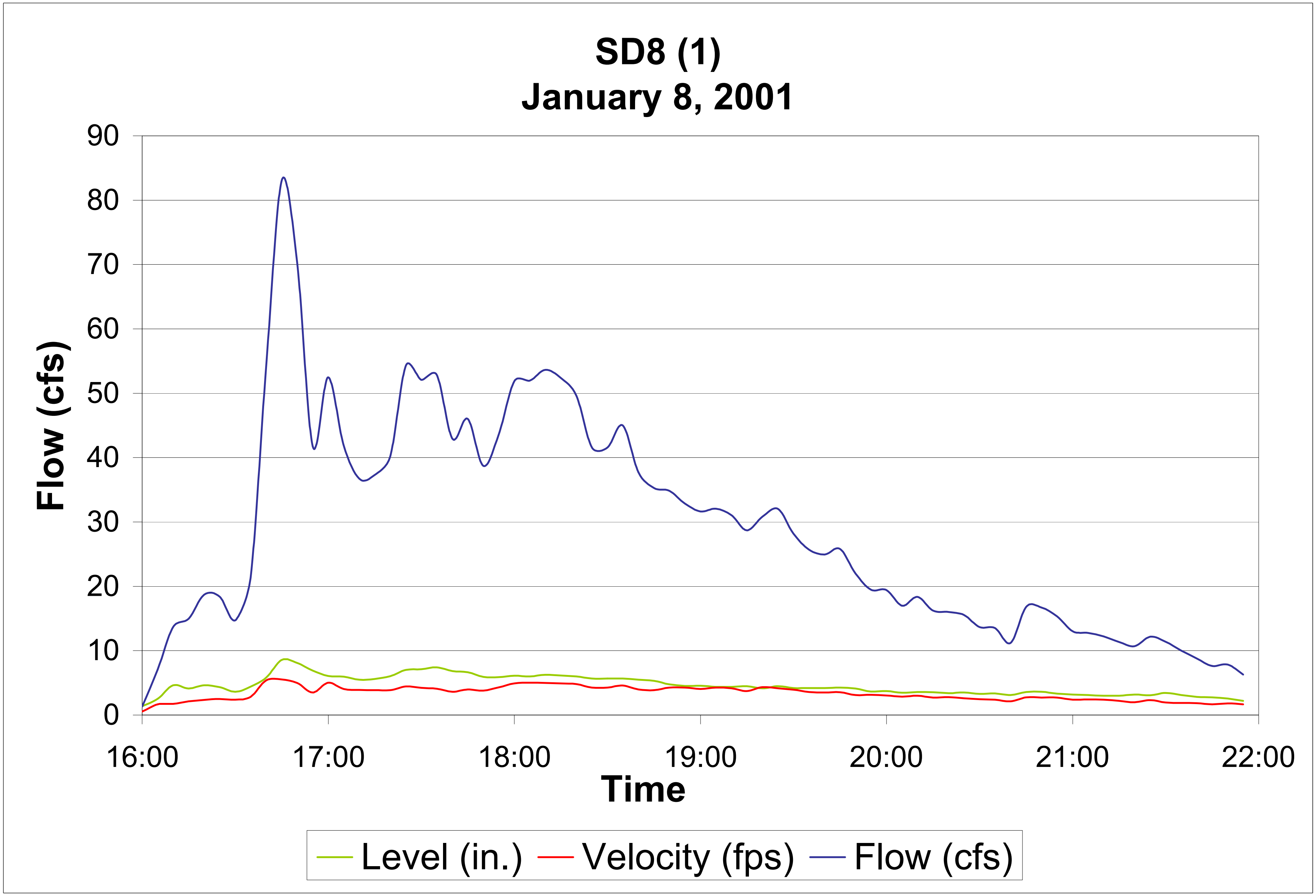
Woodward-Clyde (1996), 1995-1996 City of San Diego and Co-permittee NPDES Stormwater Monitoring Program.

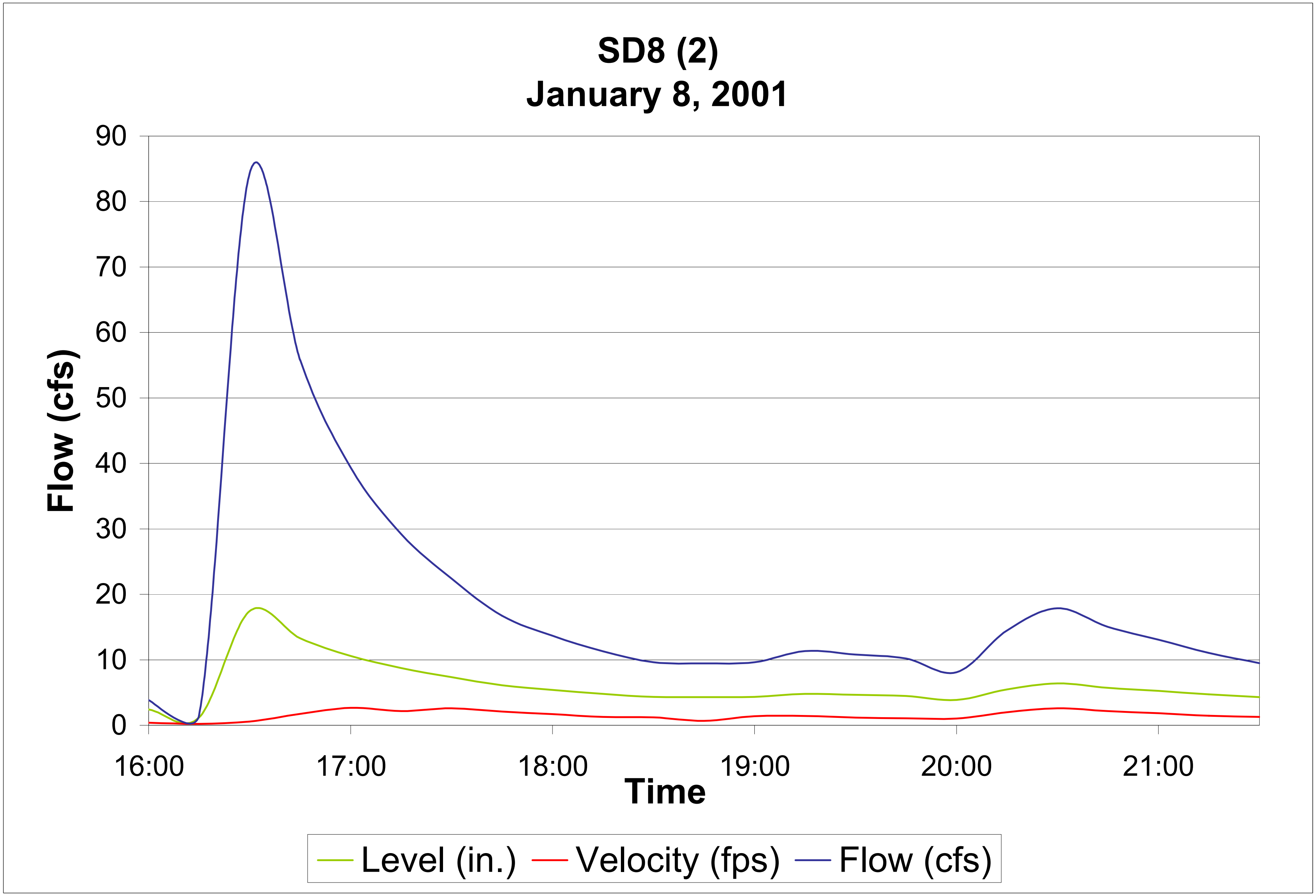
Woodward-Clyde (1997), 1996-1997 City of San Diego and Co-Permittees NPDES Stormwater Monitoring Program Report.

Woodward-Clyde (1998), 1997-1998 City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report.

APPENDIX A

Event Hydrographs


SD8 (1)
January 8, 2001
Flow (cfs)
0
10
20
30
40
50
60
70
80
90
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time
Level (in.)
Velocity (fps)
Flow (cfs)


SD8 (2)
January 8, 2001
Flow (cfs)
90
80
70
60
50
40
30
20
10
0
16:00
17:00
18:00
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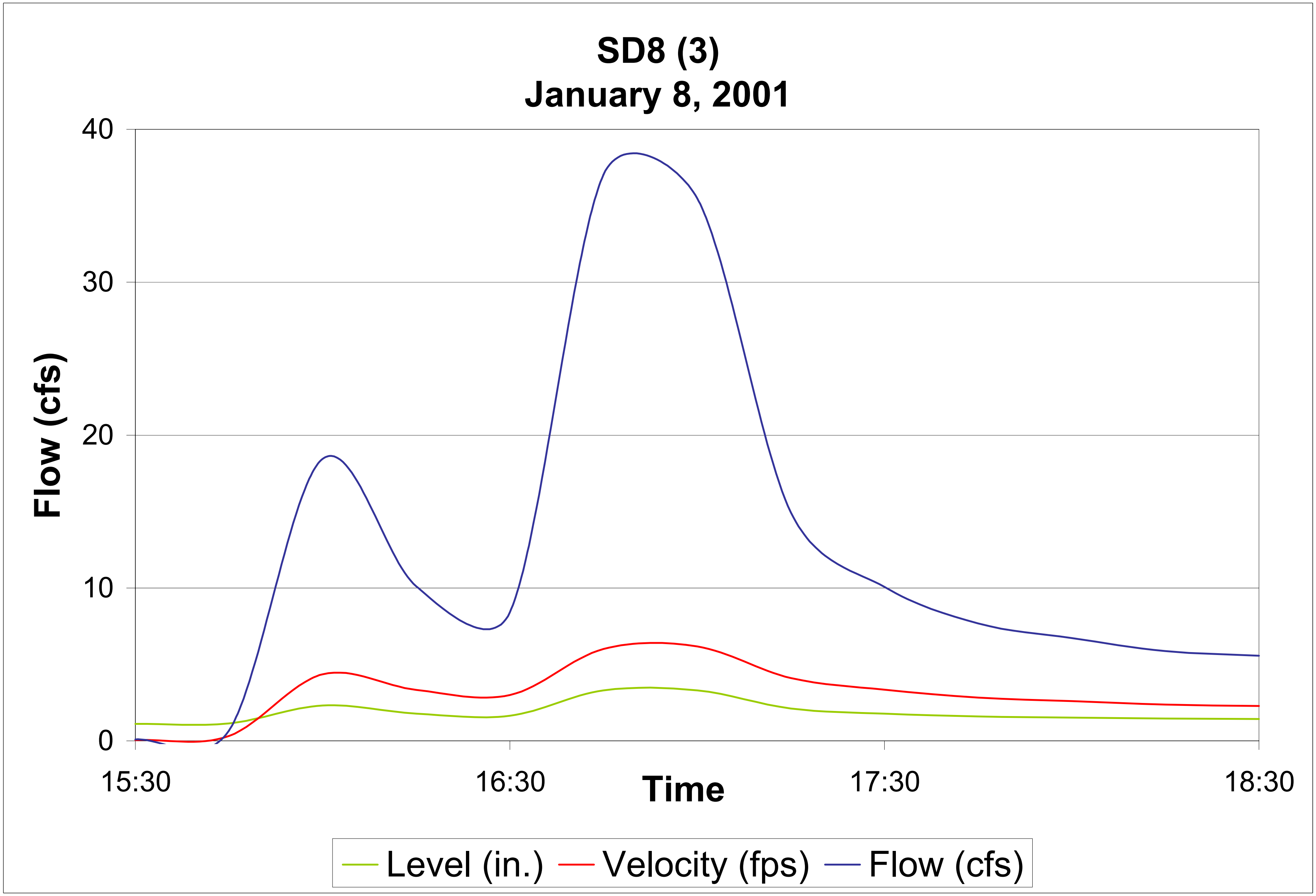
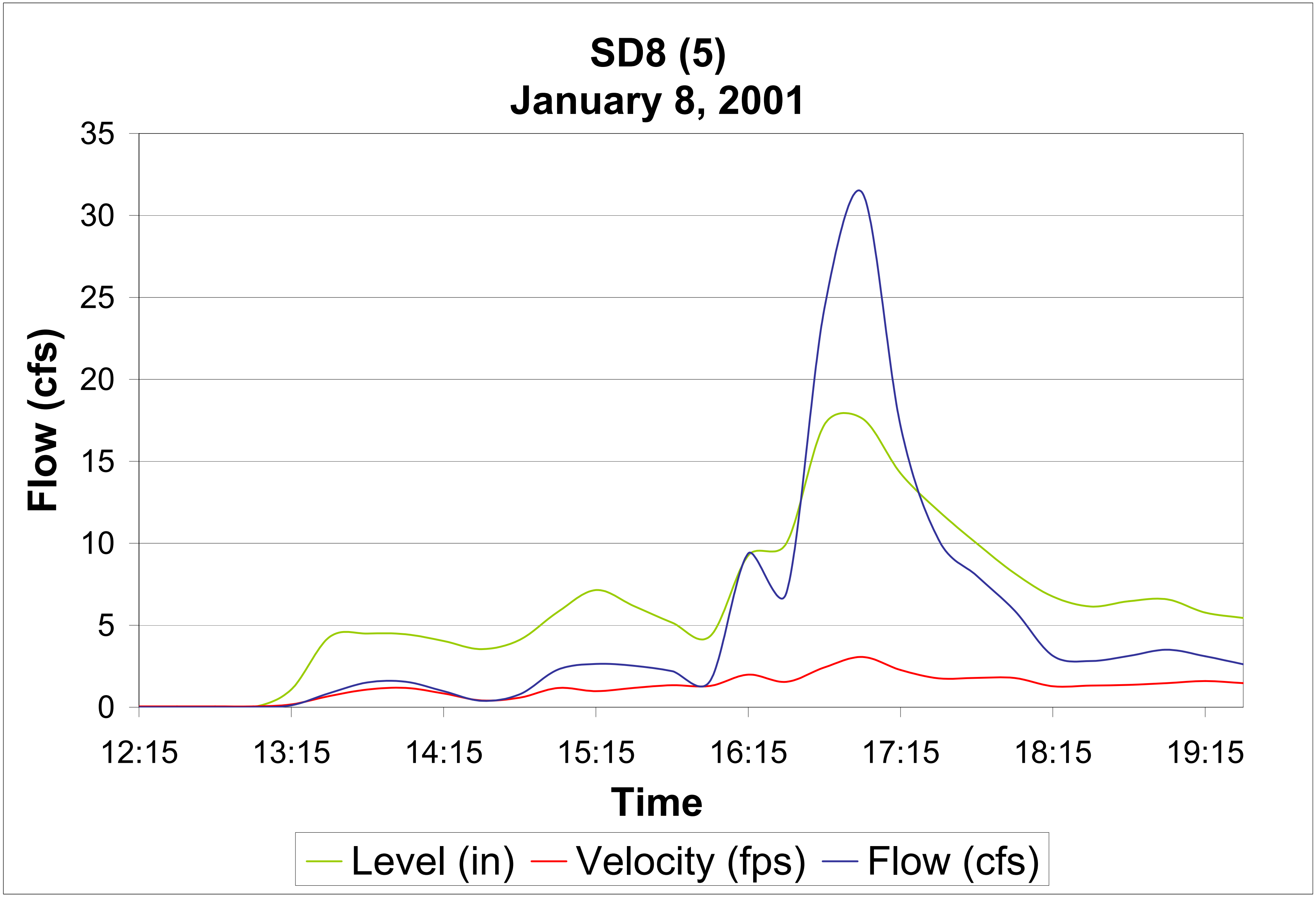
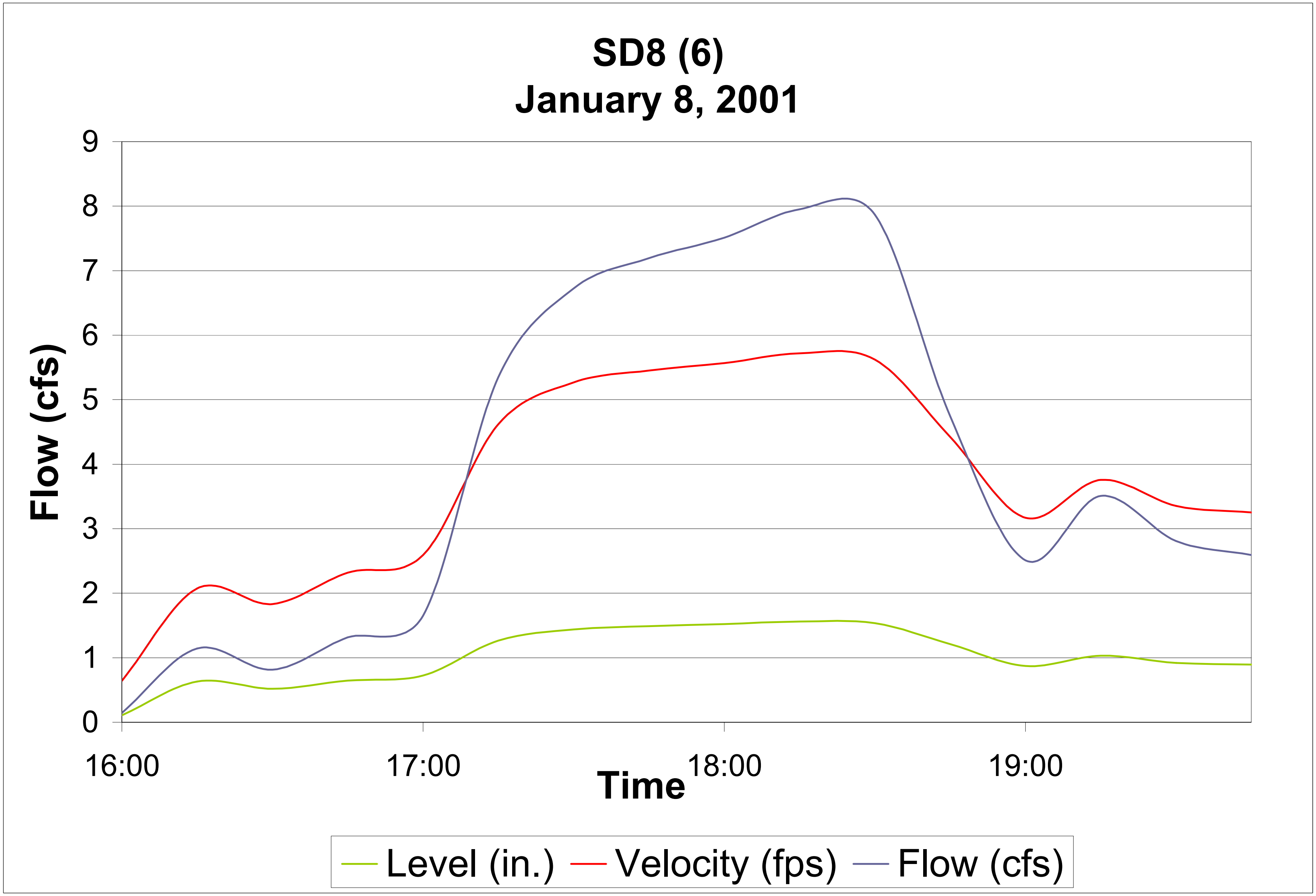
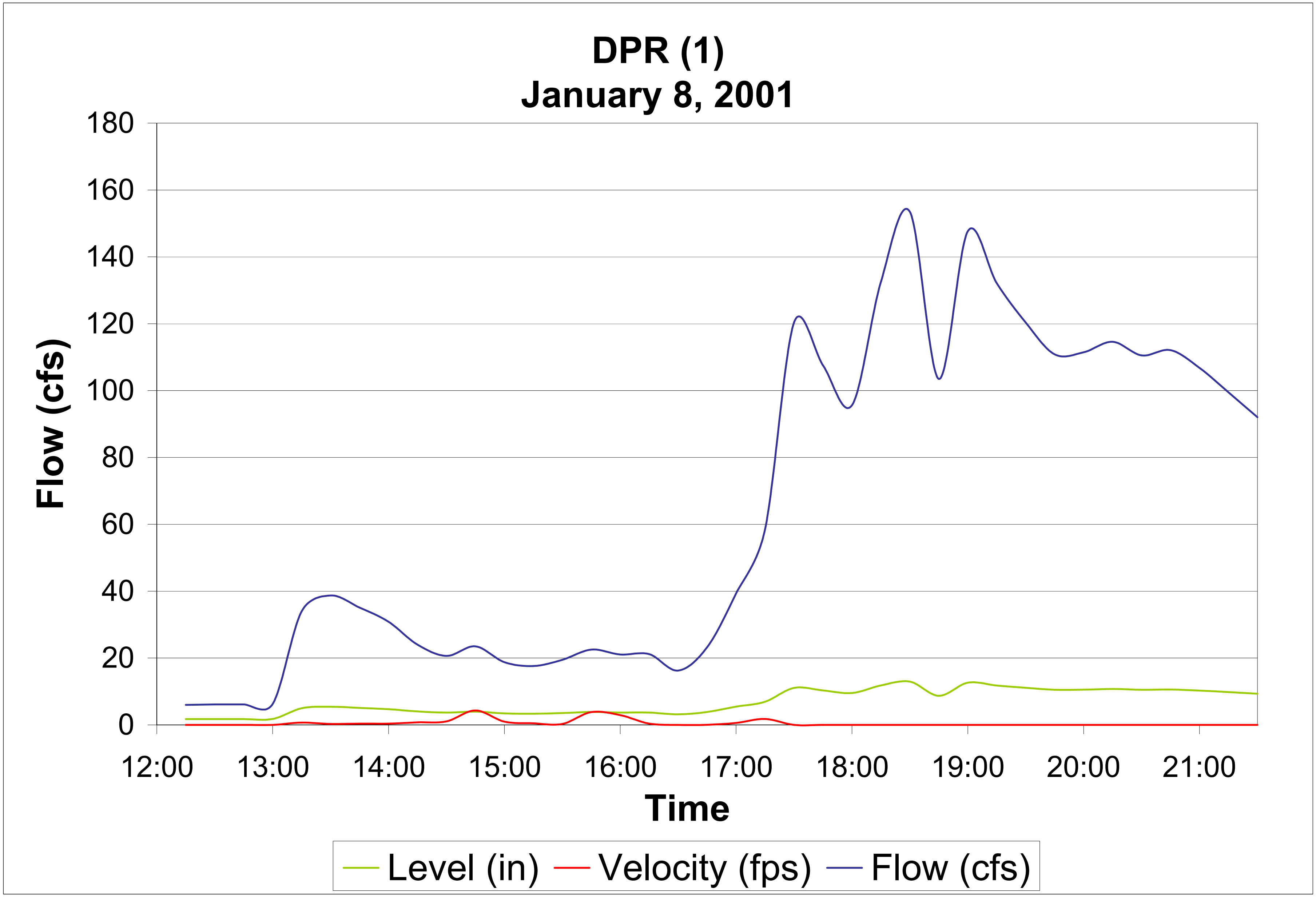
20:00
21:00
Time
Level (in.)
Velocity (fps)
Flow (cfs)


SD8 (3)
January 8, 2001
Flow (cfs)
40
30
20
10
0
15:30
16:30
17:30
18:30
Time
Level (in.)
Velocity (fps)
Flow (cfs)

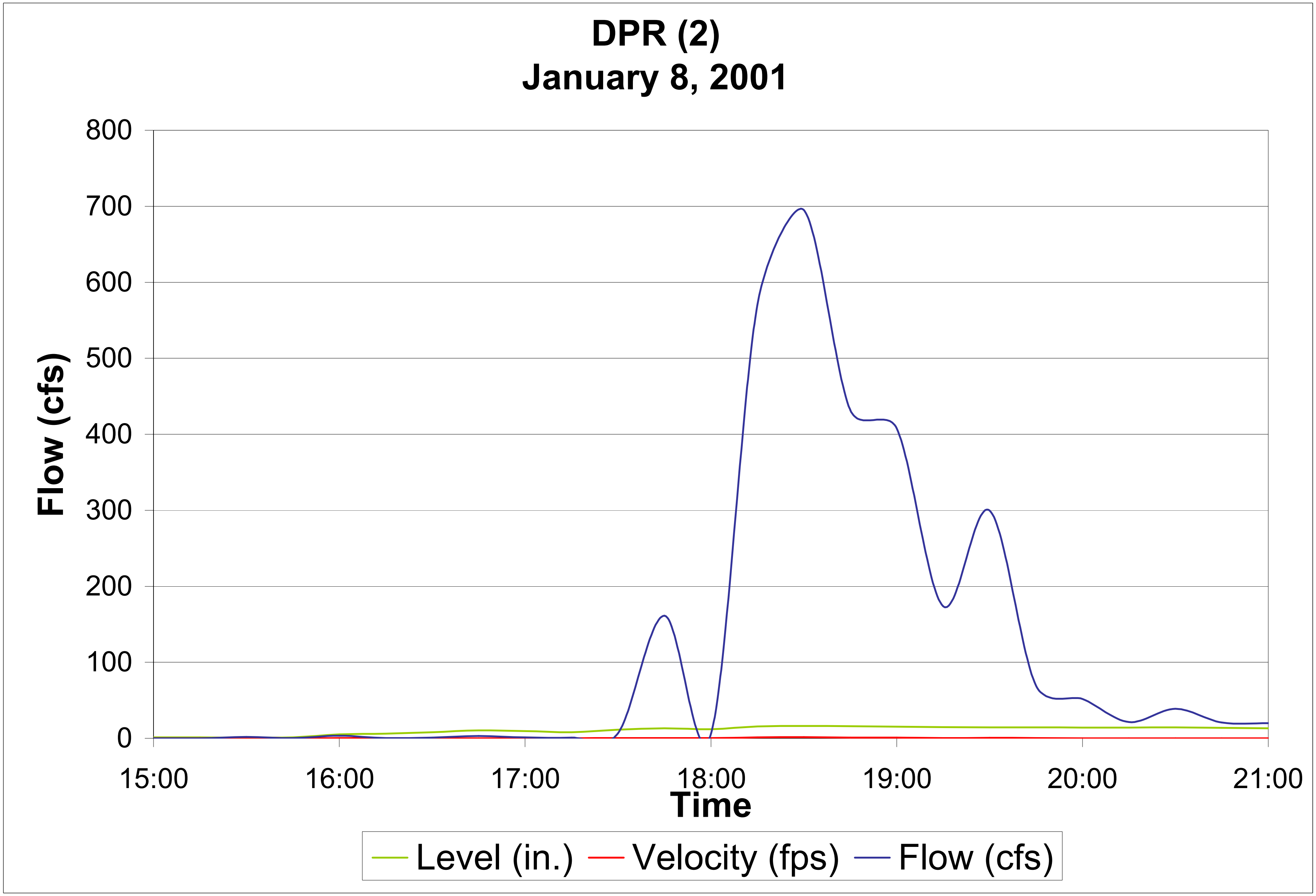


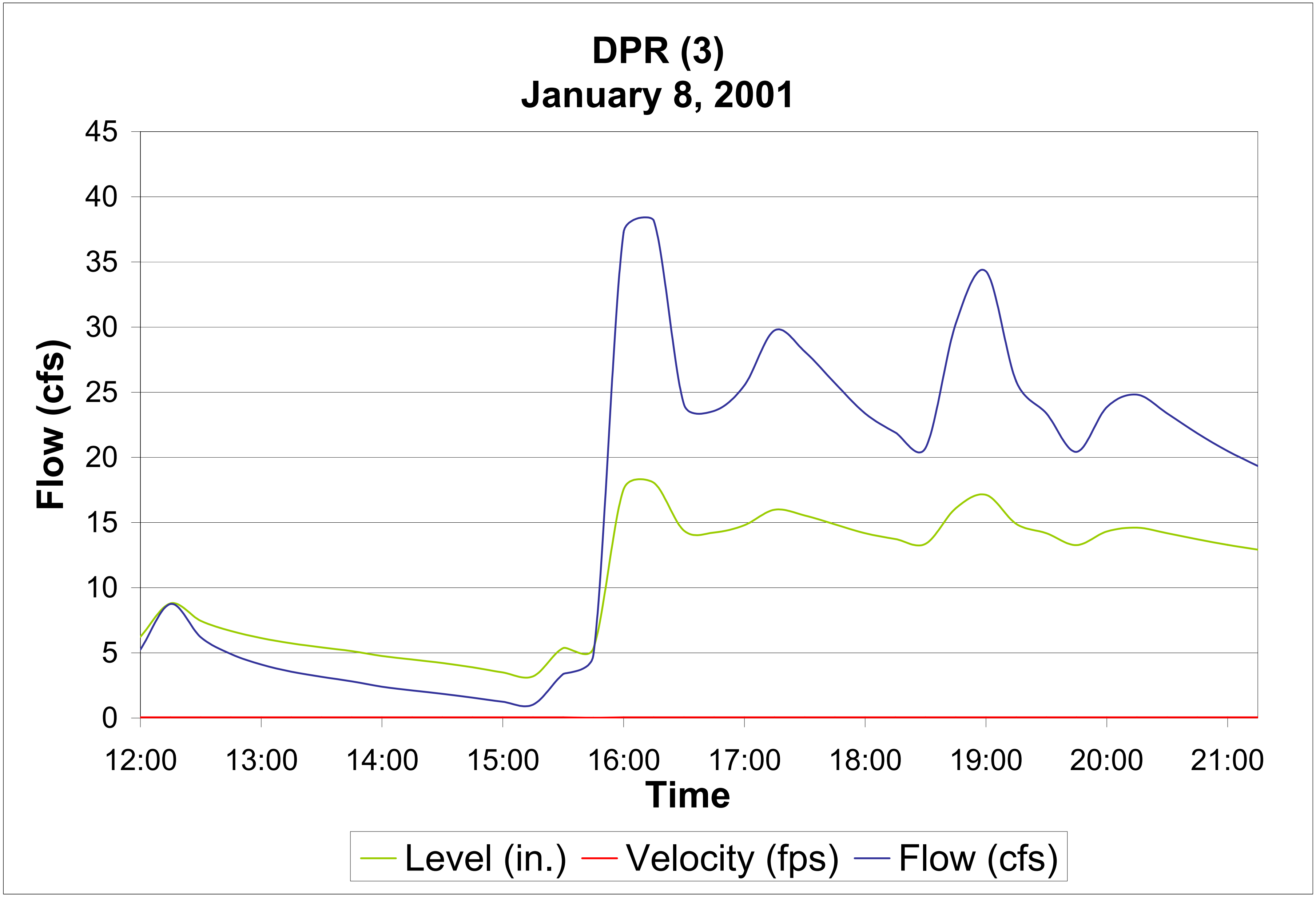
SD8 (5)
January 8, 2001
Flow (cfs)
35
30
25
20
15
10
5
0
12:15
13:15
14:15
15:15
16:15
17:15
18:15
19:15
Time
Level (in)
Velocity (fps)
Flow (cfs)

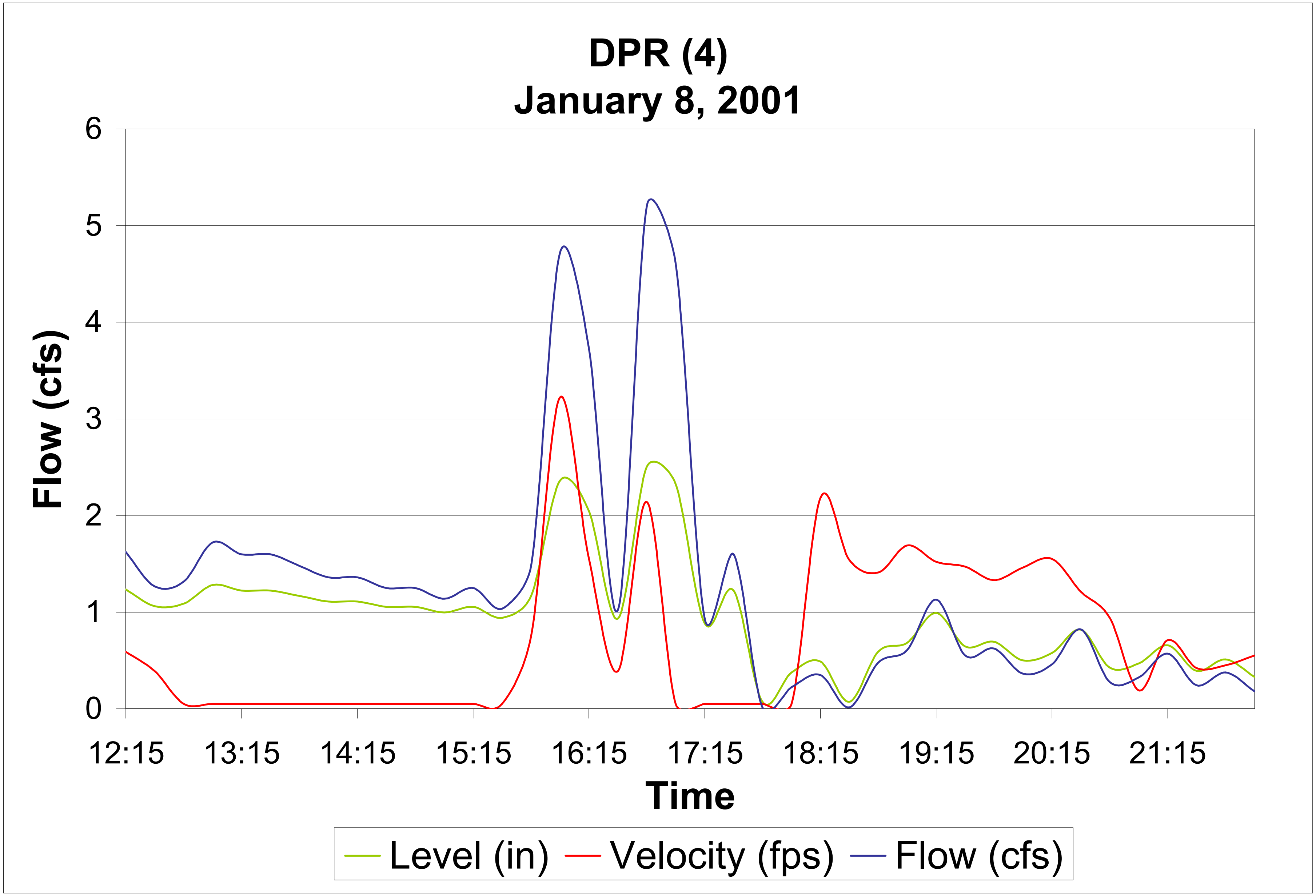

SD8 (6)
January 8, 2001
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
16:00
17:00
18:00
19:00
Time
Level (in.)
Velocity (fps)
Flow (cfs)



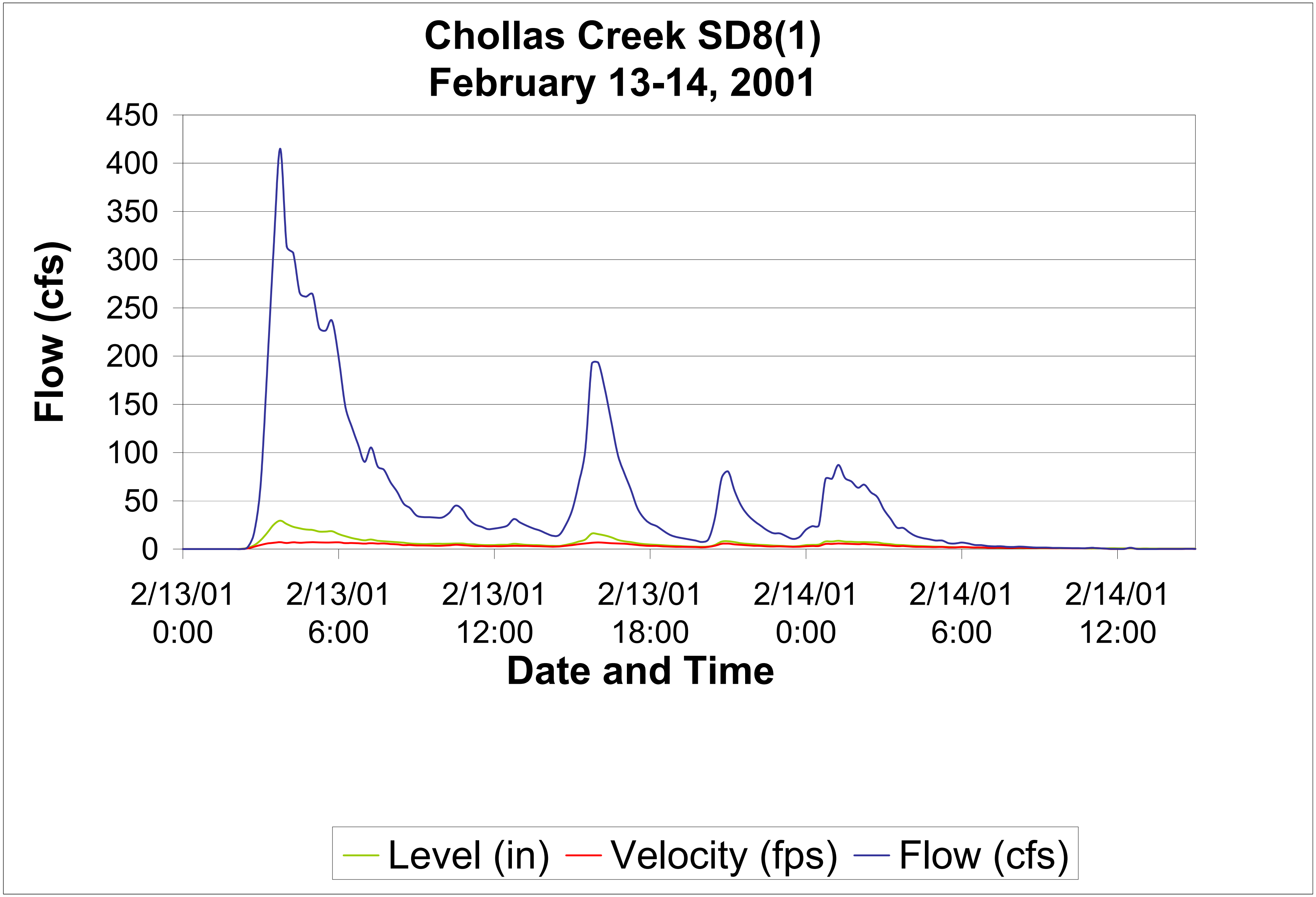
DPR (1)
January 8, 2001
Flow (cfs)
180
160
140
120
100
80
60
40
20
0
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
Time
Level (in)
Velocity (fps)
Flow (cfs)


DPR (2)
January 8, 2001
Flow (cfs)
800
700
600
500
400
300
200
100
0
15:00
16:00
17:00
18:00
19:00
20:00
21:00
Time
Level (in.)
Velocity (fps)
Flow (cfs)

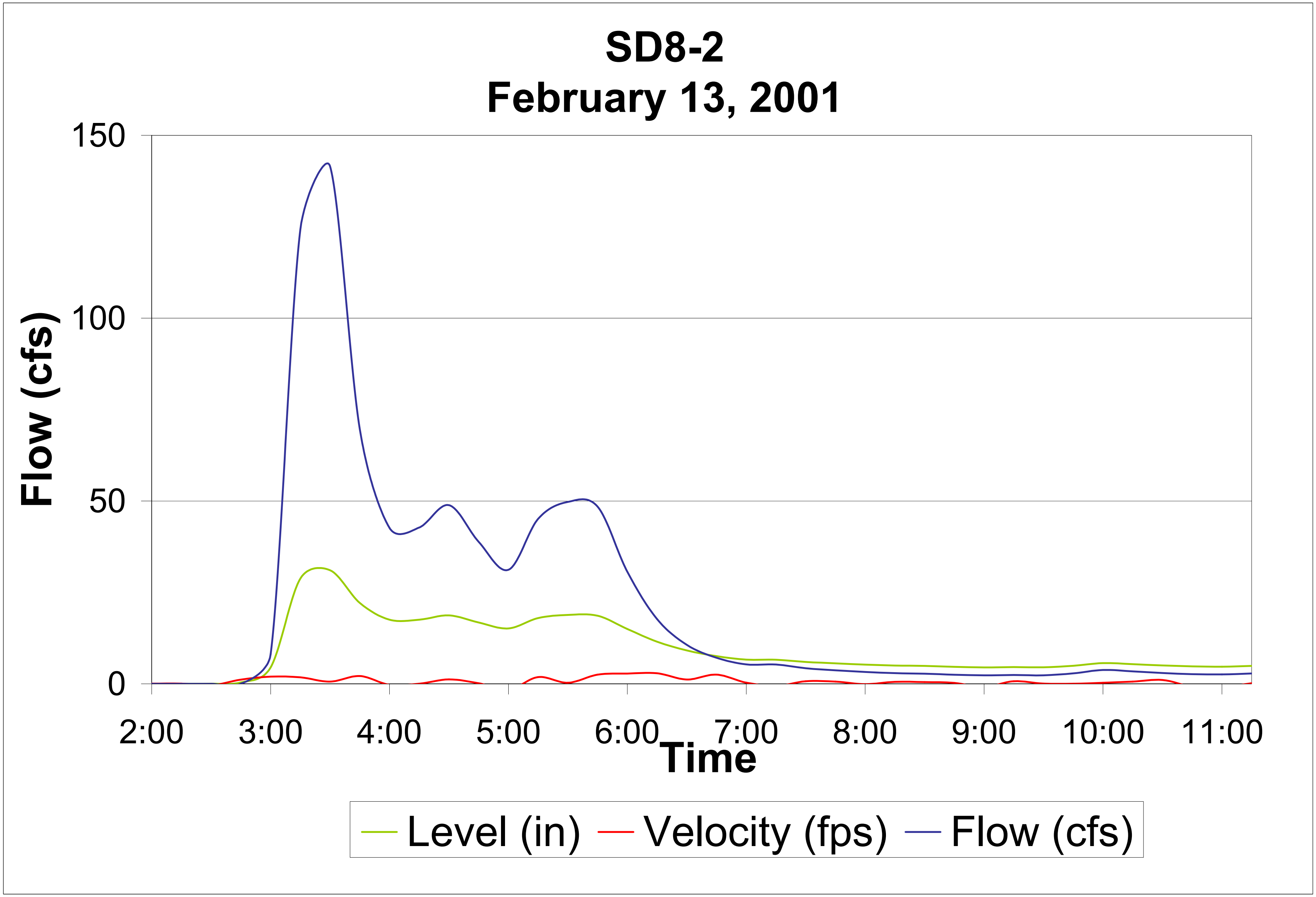

DPR (3)
January 8, 2001
Flow (cfs)
45
40
35
30
25
20
15
10
5
0
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
Time
Level (in.)
Velocity (fps)
Flow (cfs)



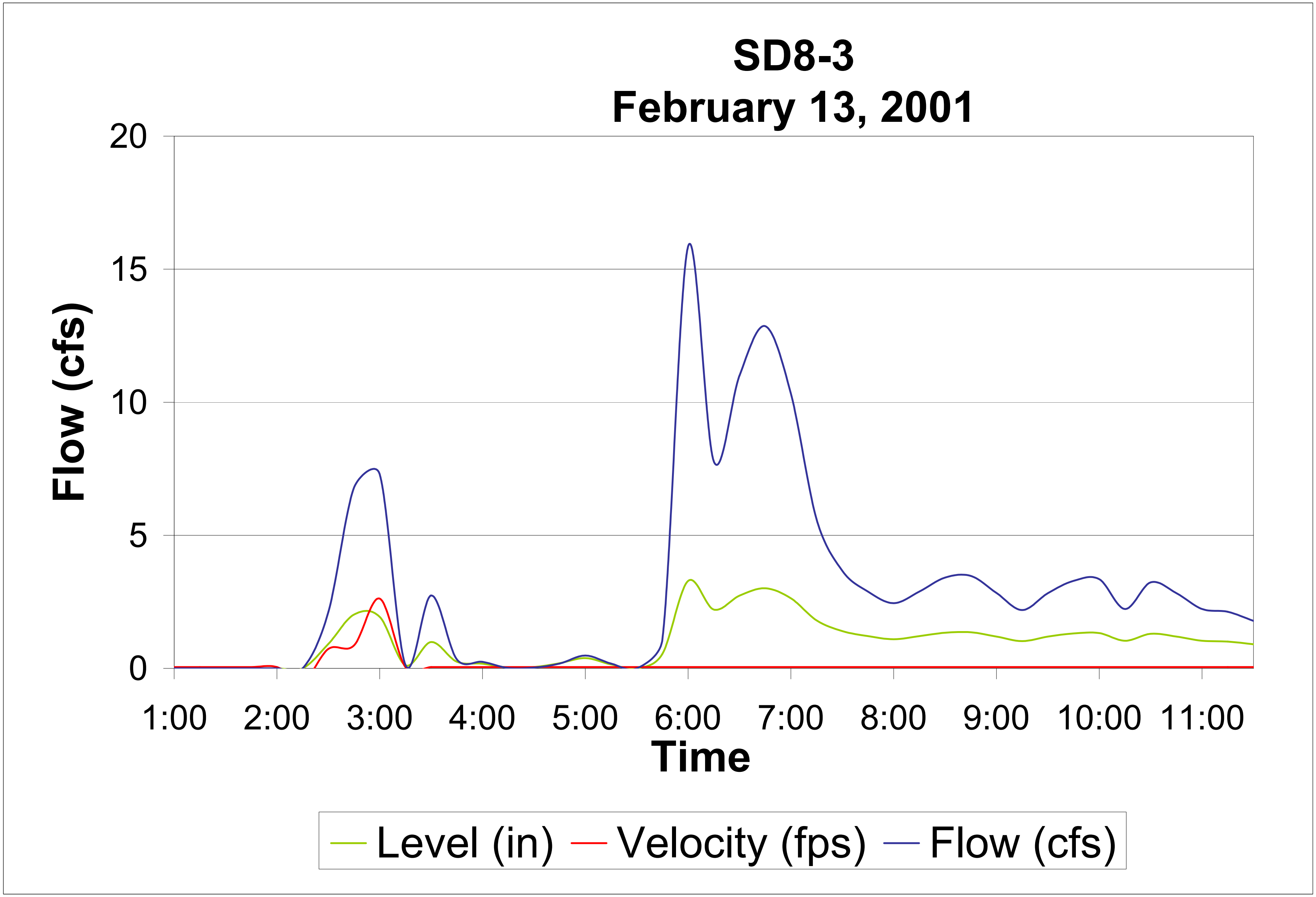
DPR (4)
January 8, 2001
Flow (cfs)
6
5
4
3
2
1
0
12:15
13:15
14:15
15:15
16:15
17:15
18:15
19:15
20:15
21:15
Time
Level (in)
Velocity (fps)
Flow (cfs)

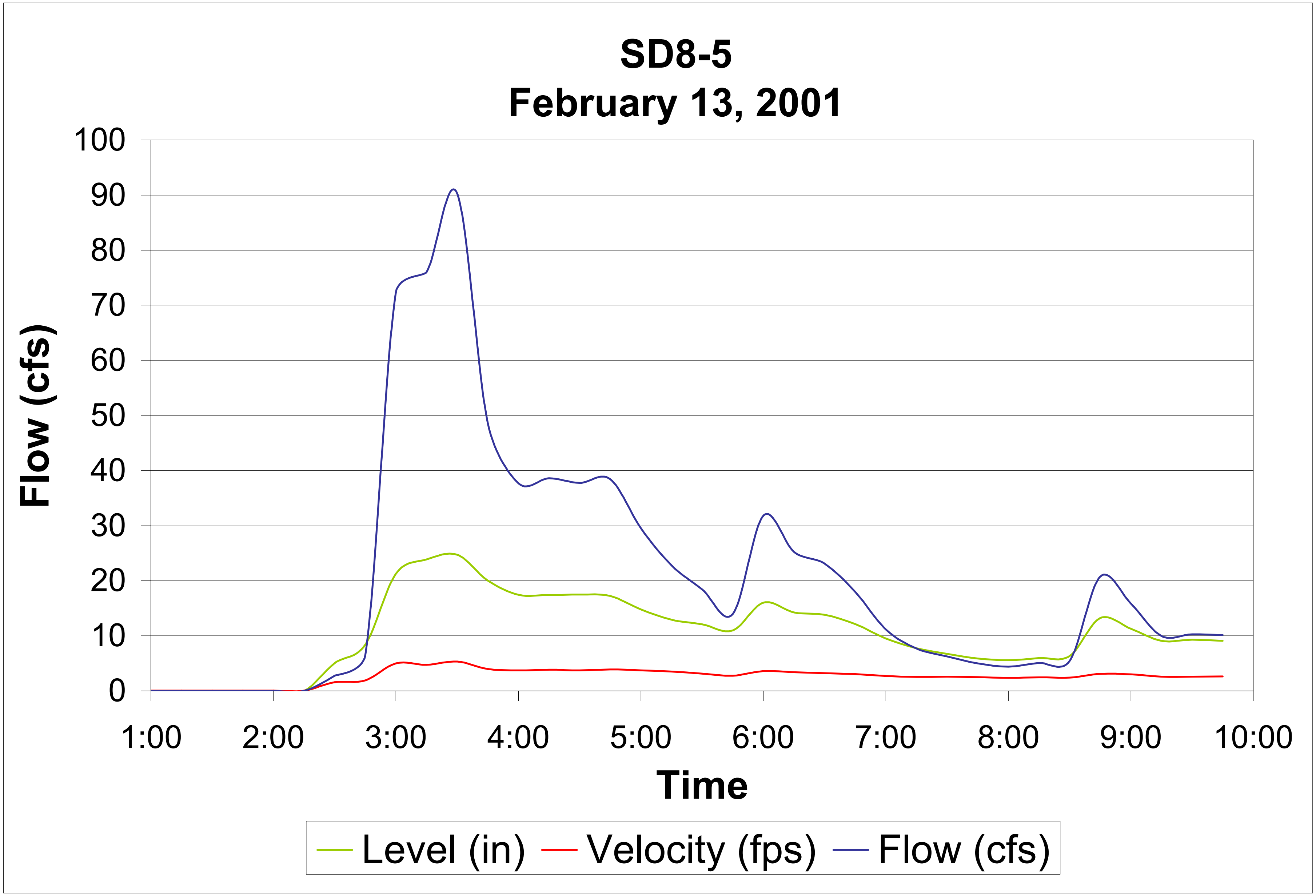


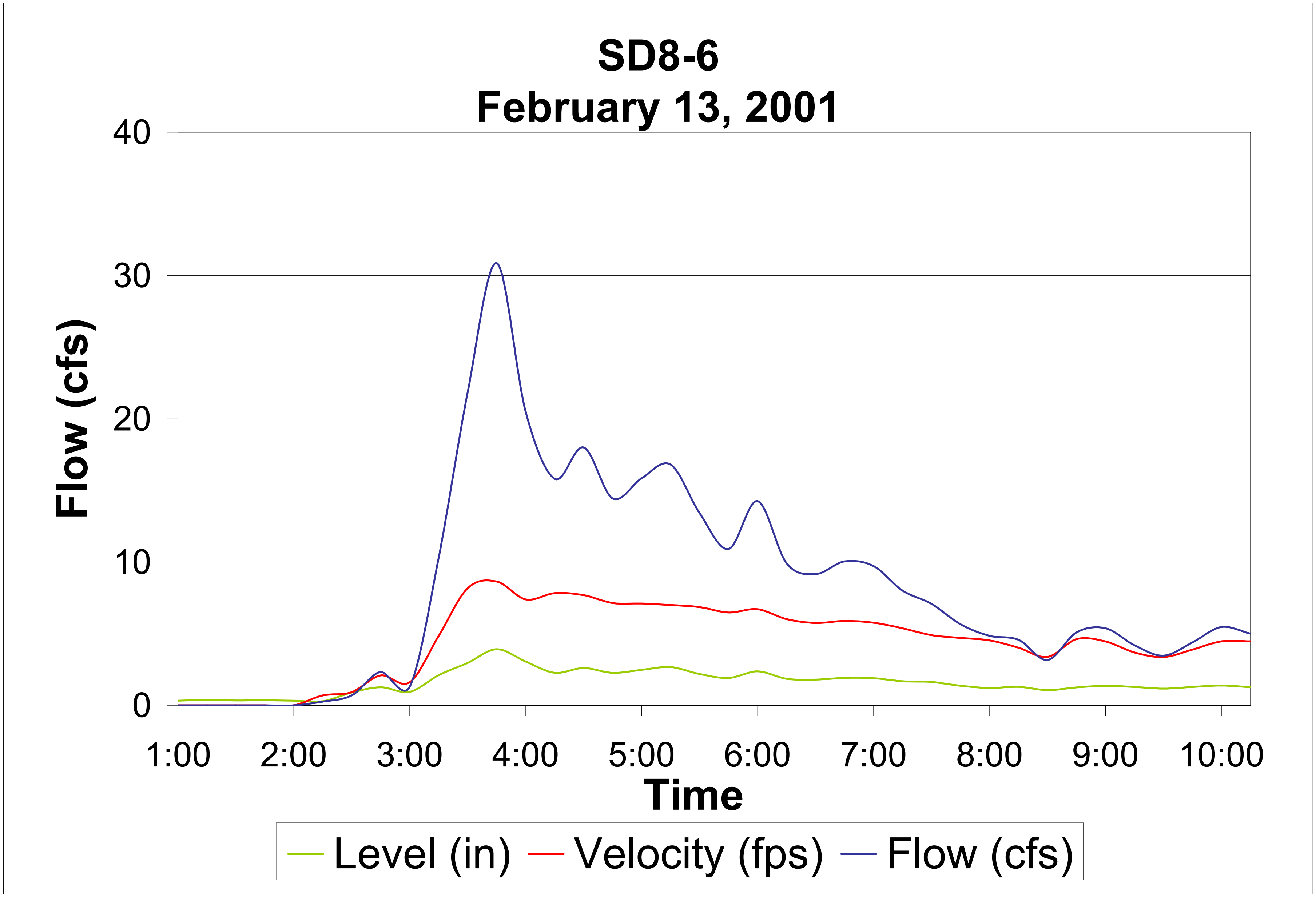
Chollas Creek SD8(1)
February 13-14, 2001
Flow (cfs)
450
400
350
300
250
200
150
100
50
0
2/13/01 0:00
2/13/01 6:00
2/13/01 12:00
2/13/01 18:00
2/14/01 0:00
2/14/01 6:00
2/14/01 12:00
Date and Time
Level (in)
Velocity (fps)
Flow (cfs)

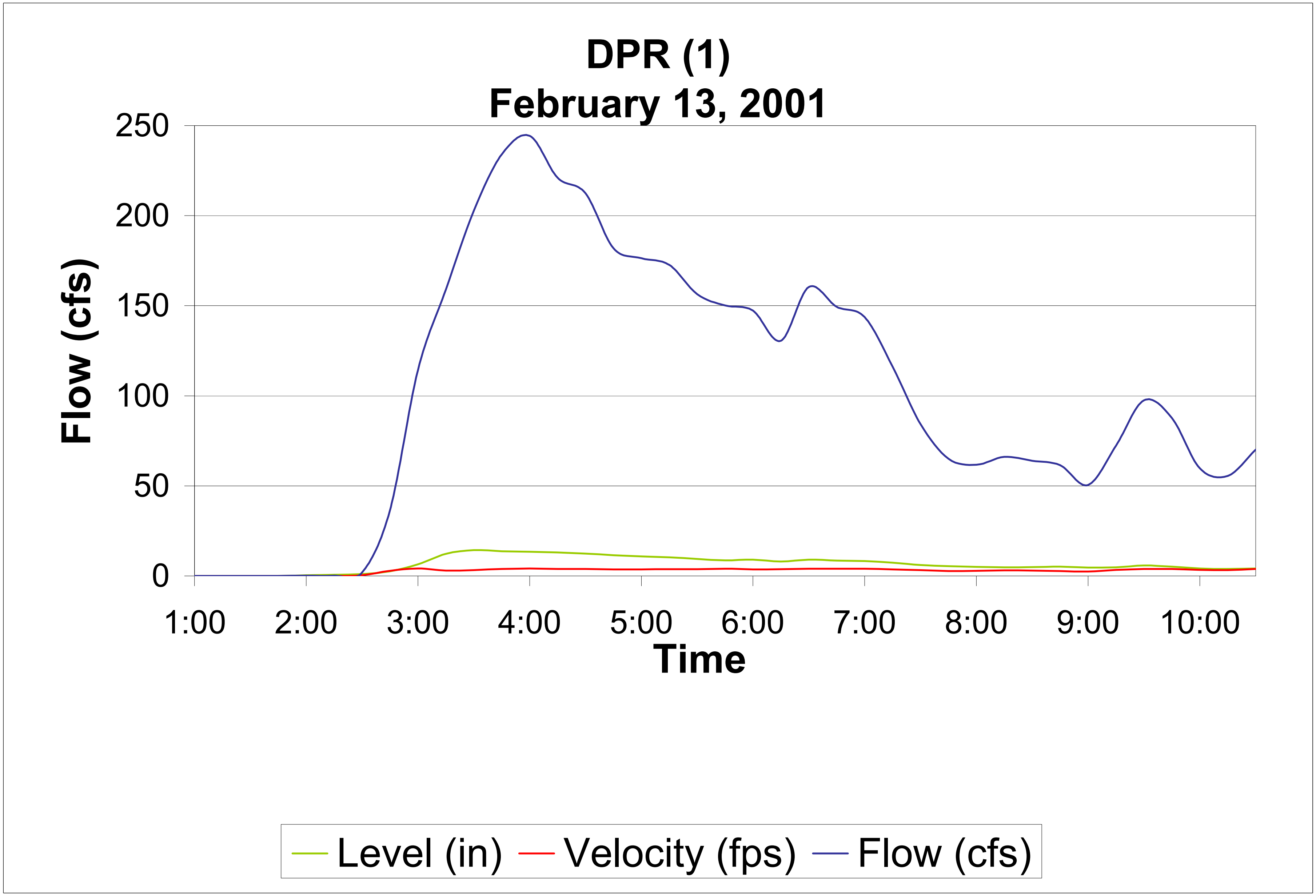


SD8-2
February 13, 2001
Flow (cfs)
150
100
50
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

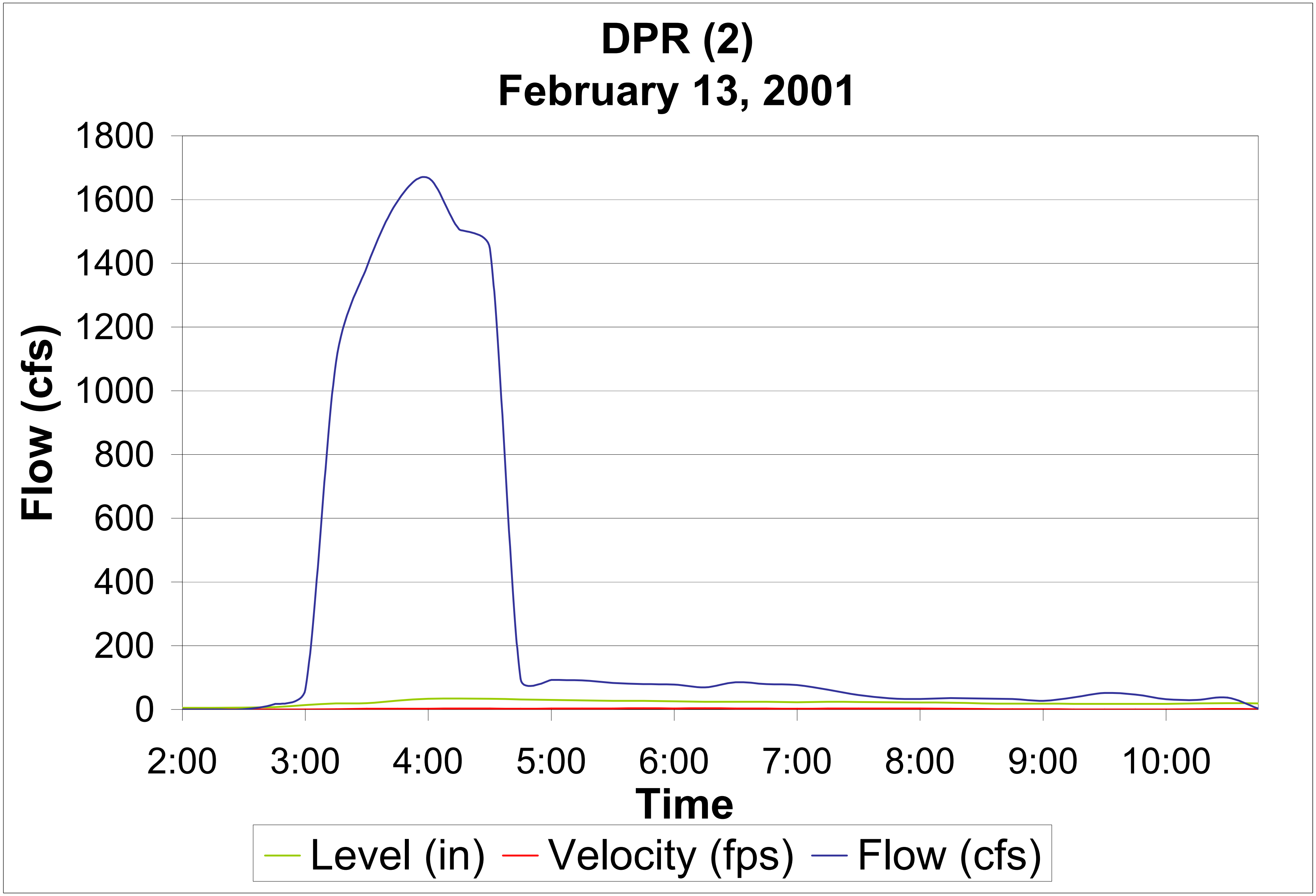

SD8-3
February 13, 2001
Flow (cfs)
20
15
10
5
0
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

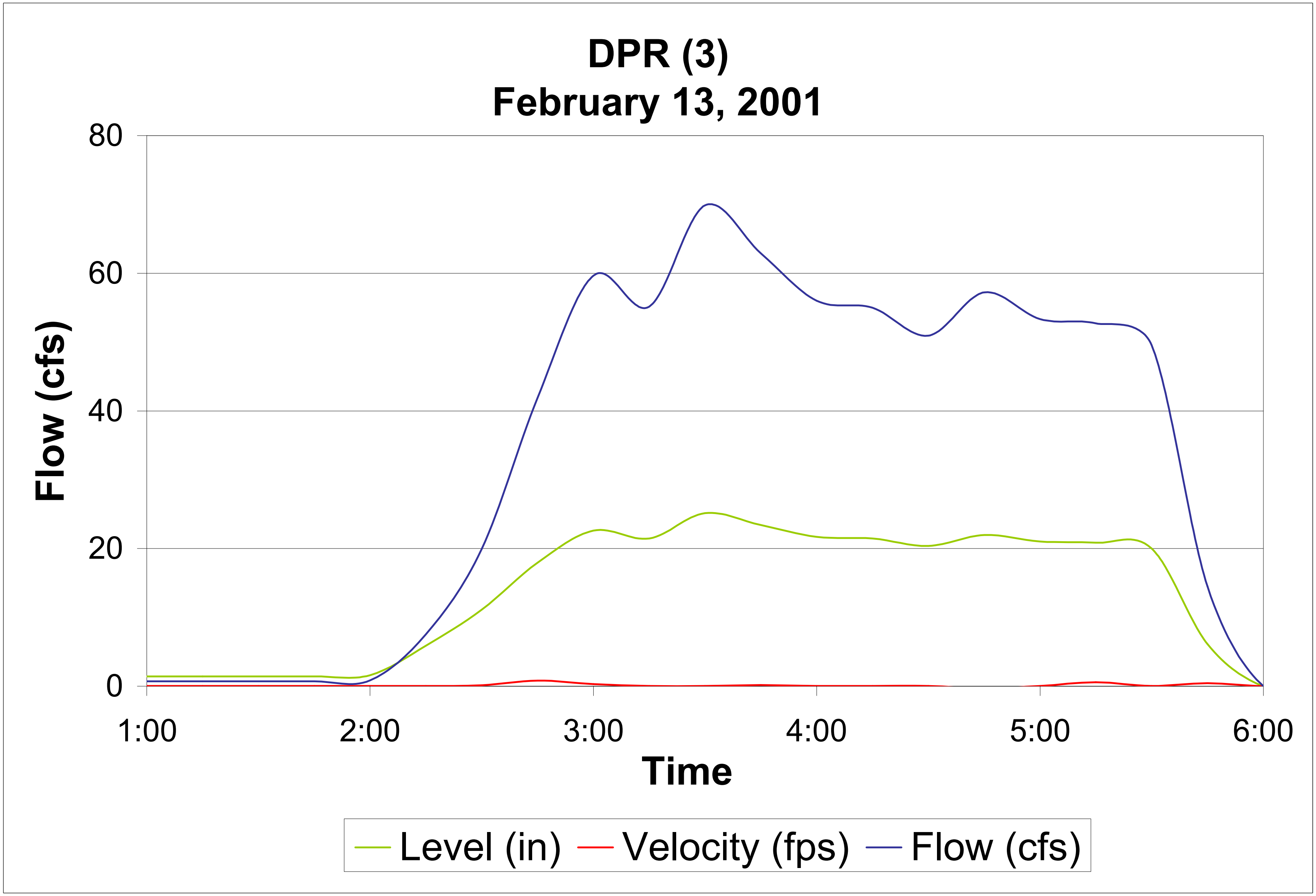

SD8-5
February 13, 2001
Flow (cfs)
100
90
80
70
60
50
40
30
20
10
0
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

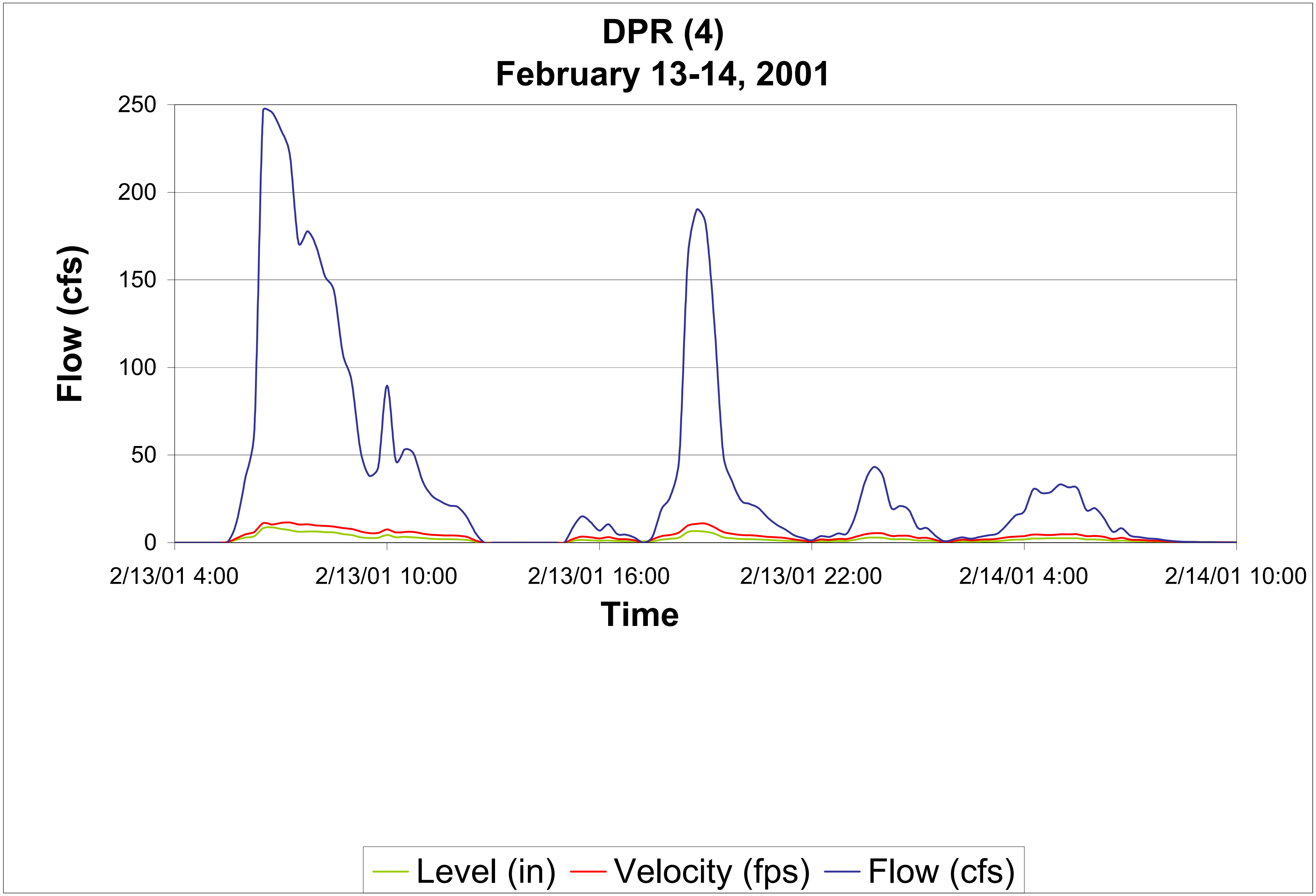

SD8-6
February 13, 2001
Flow (cfs)
40
30
20
10
0
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

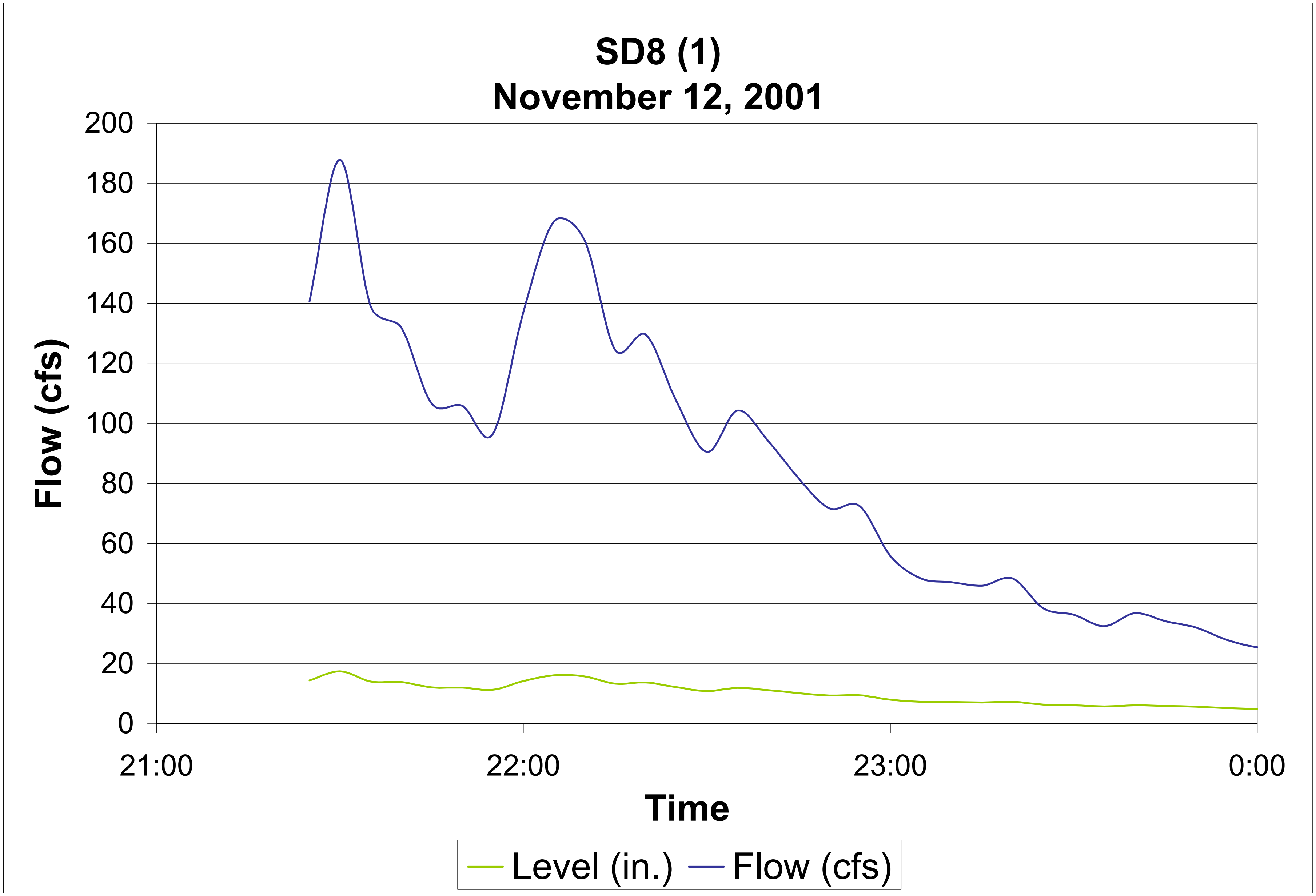


DPR (1)
February 13, 2001
Flow (cfs)
250
200
150
100
50
0
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

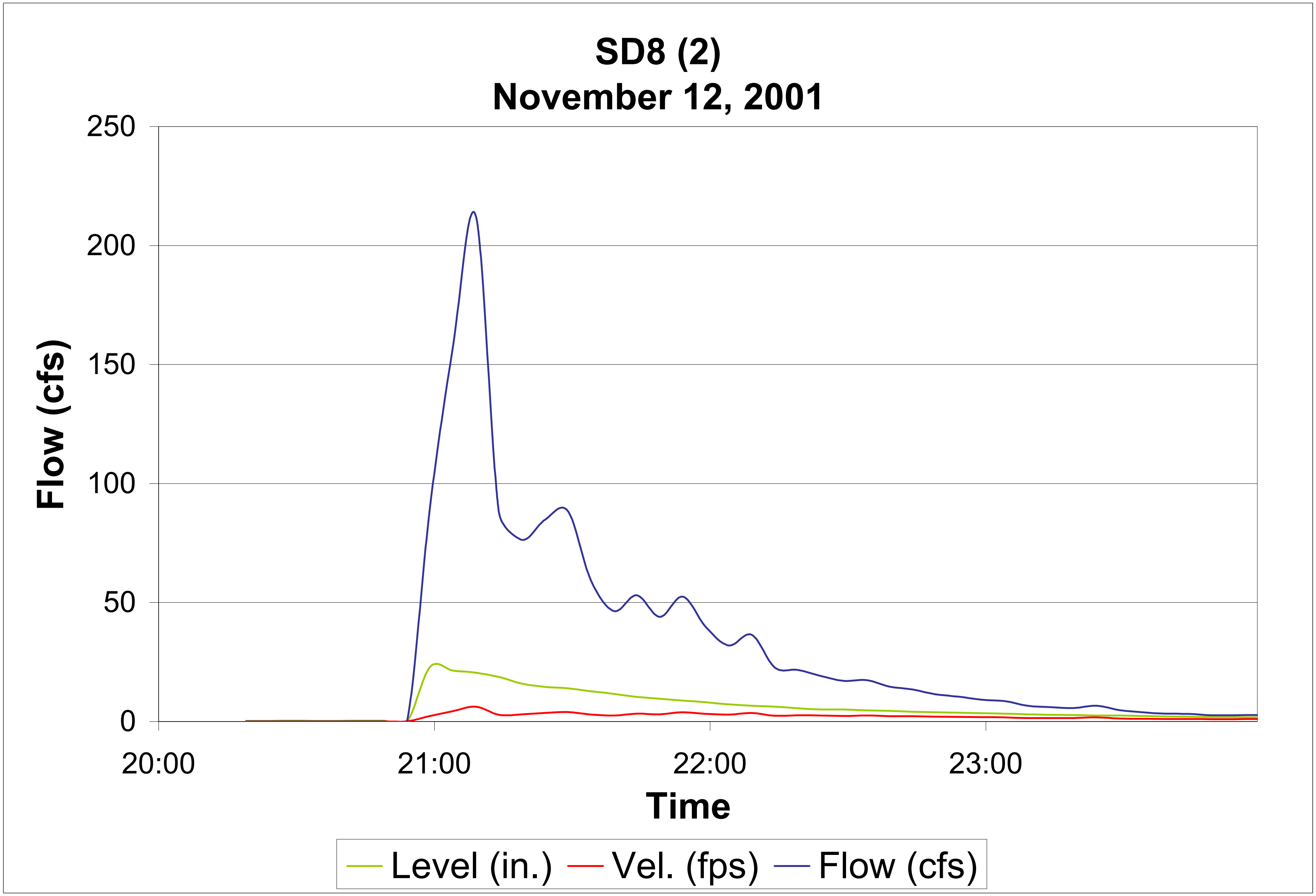

DPR (2)
February 13, 2001
Flow (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

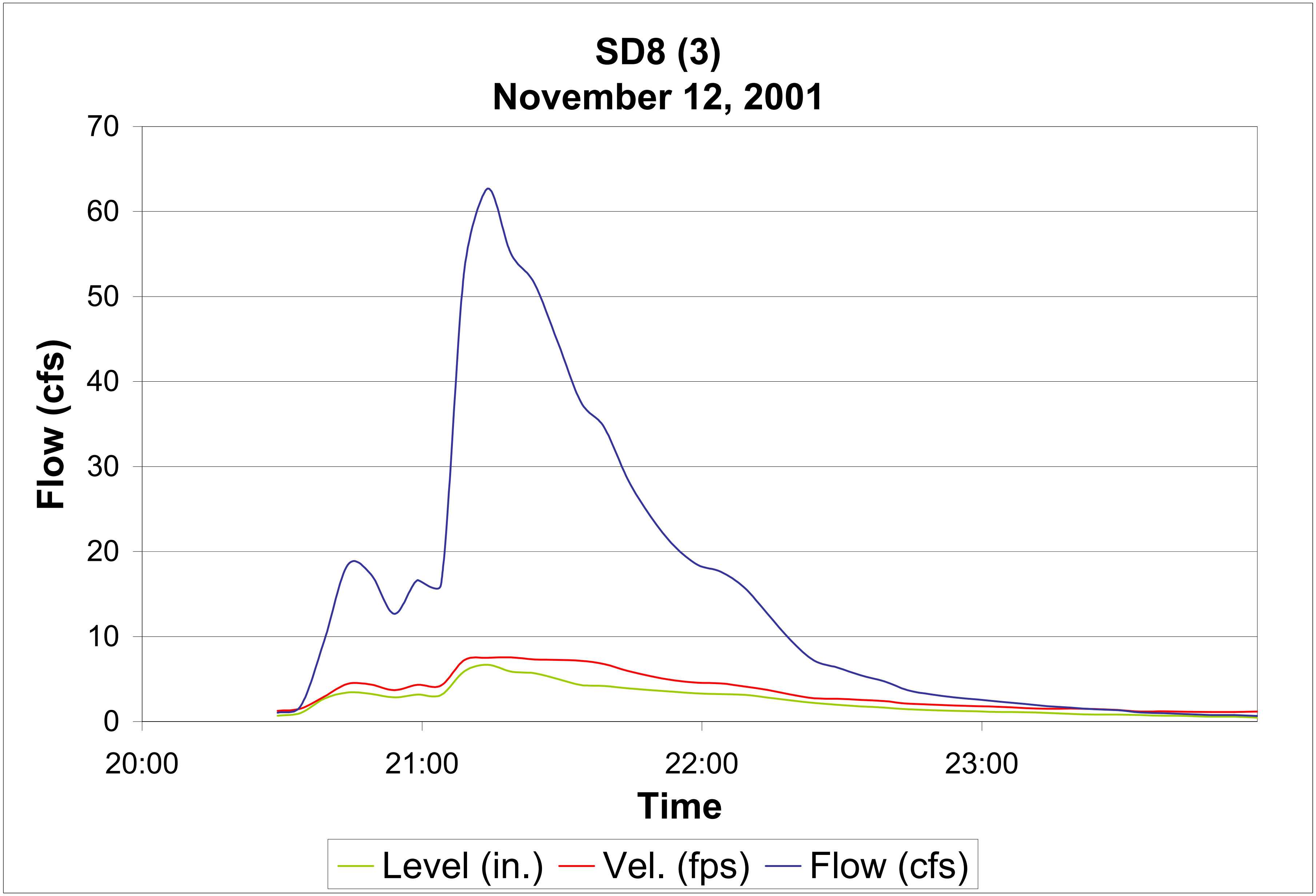

DPR (3)
February 13, 2001
Flow (cfs)
80
60
40
20
0
1:00
2:00
3:00
4:00
5:00
6:00
Time
Level (in)
Velocity (fps)
Flow (cfs)

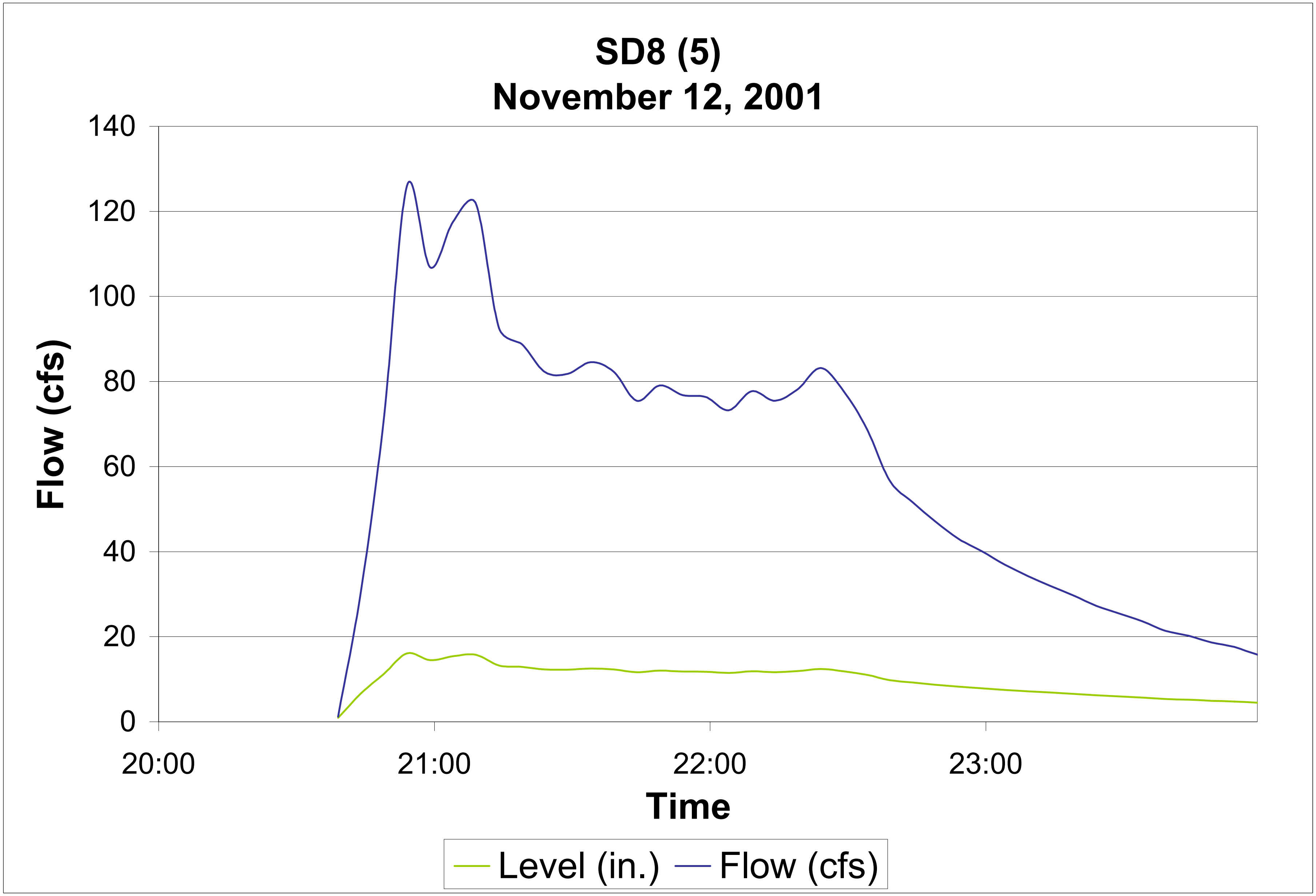

DPR (4)
February 13-14, 2001
Flow (cfs)
250
200
150
100
50
0
2/13/01 4:00
2/13/01 10:00
2/13/01 16:00
2/13/01 22:00
2/14/01 4:00
2/14/01 10:00
Time
Level (in)
Velocity (fps)
Flow (cfs)



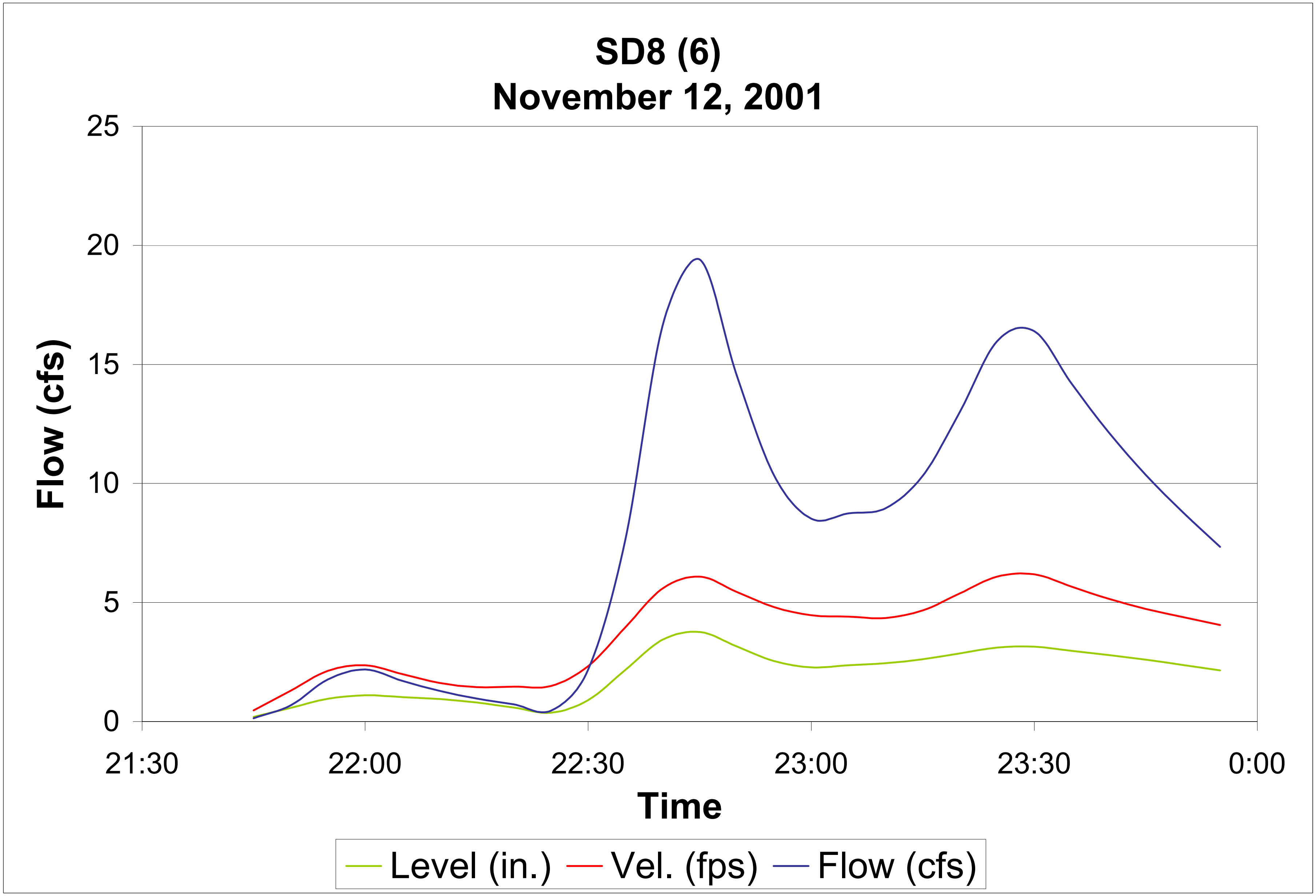
SD8 (1)
November 12, 2001
Flow (cfs)
200
180
160
140
120
100
80
60
40
20
0
21:00
22:00
23:00
0:00
Time
Level (in.)
Flow (cfs)

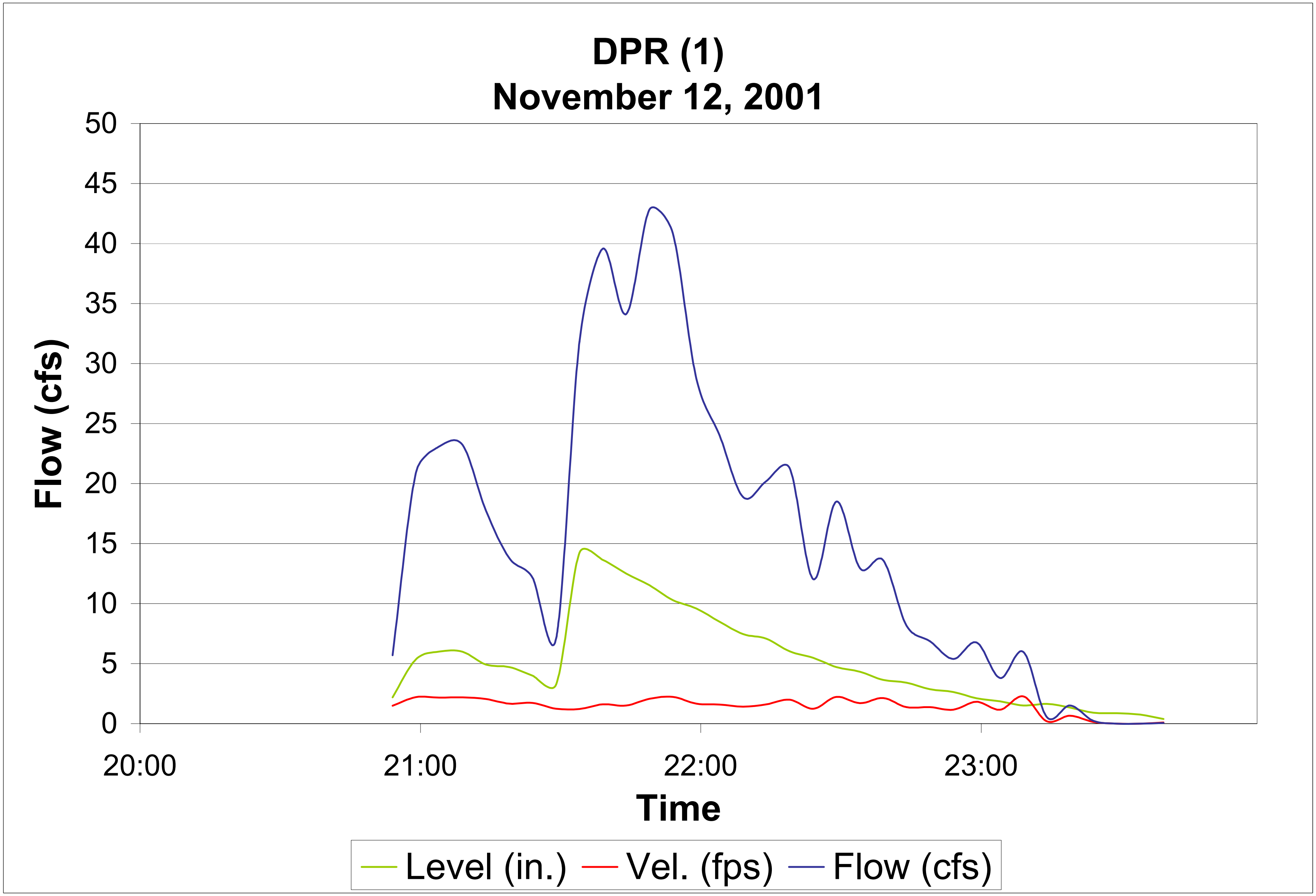

SD8 (2)
November 12, 2001
Flow (cfs)
250
200
150
100
50
0
20:00
21:00
22:00
23:00
Time
Level (in.)
Vel. (fps)
Flow (cfs)


SD8 (3)
November 12, 2001
Flow (cfs)
70
60
50
40
30
20
10
0
20:00
21:00
22:00
23:00
Time
Level (in.)
Vel. (fps)
Flow (cfs)

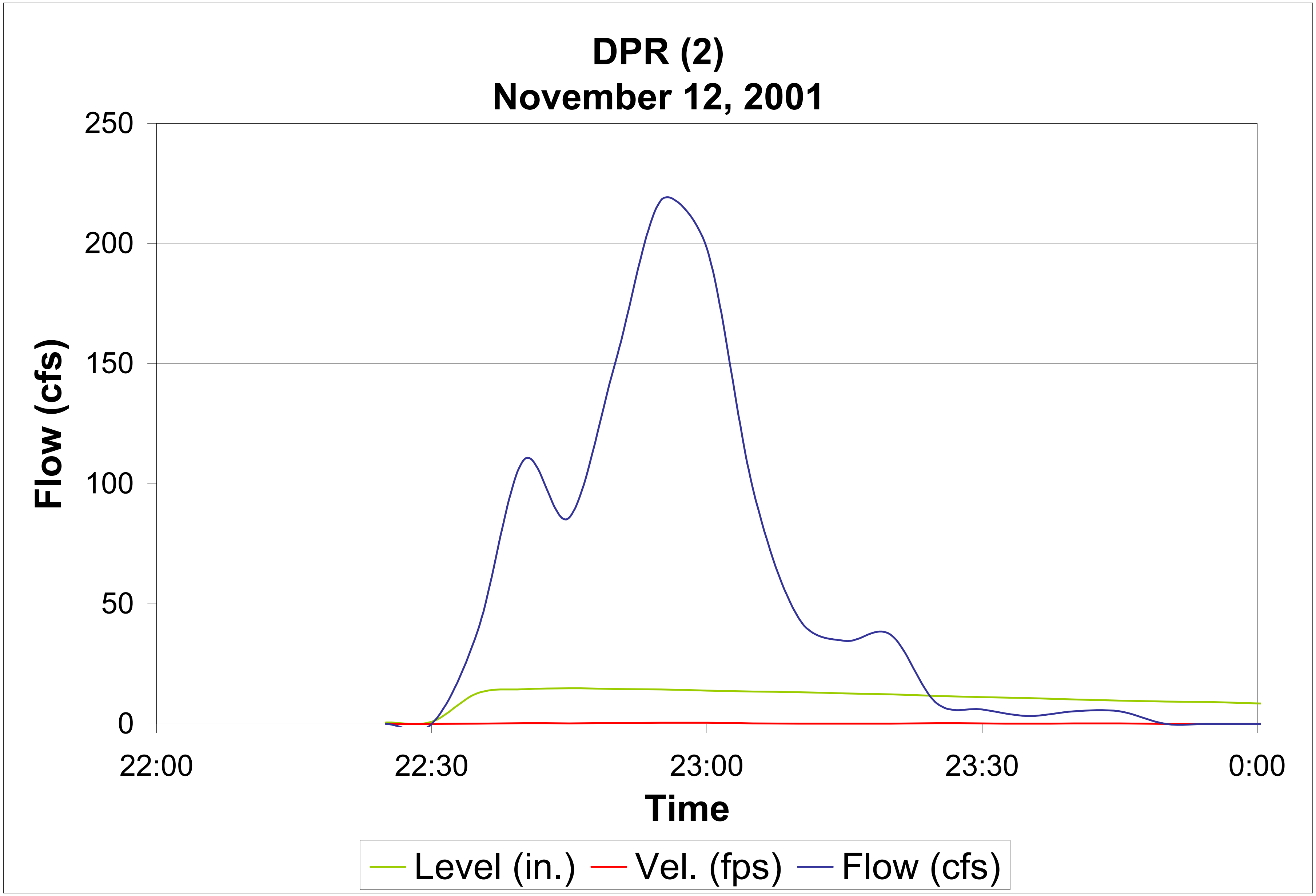


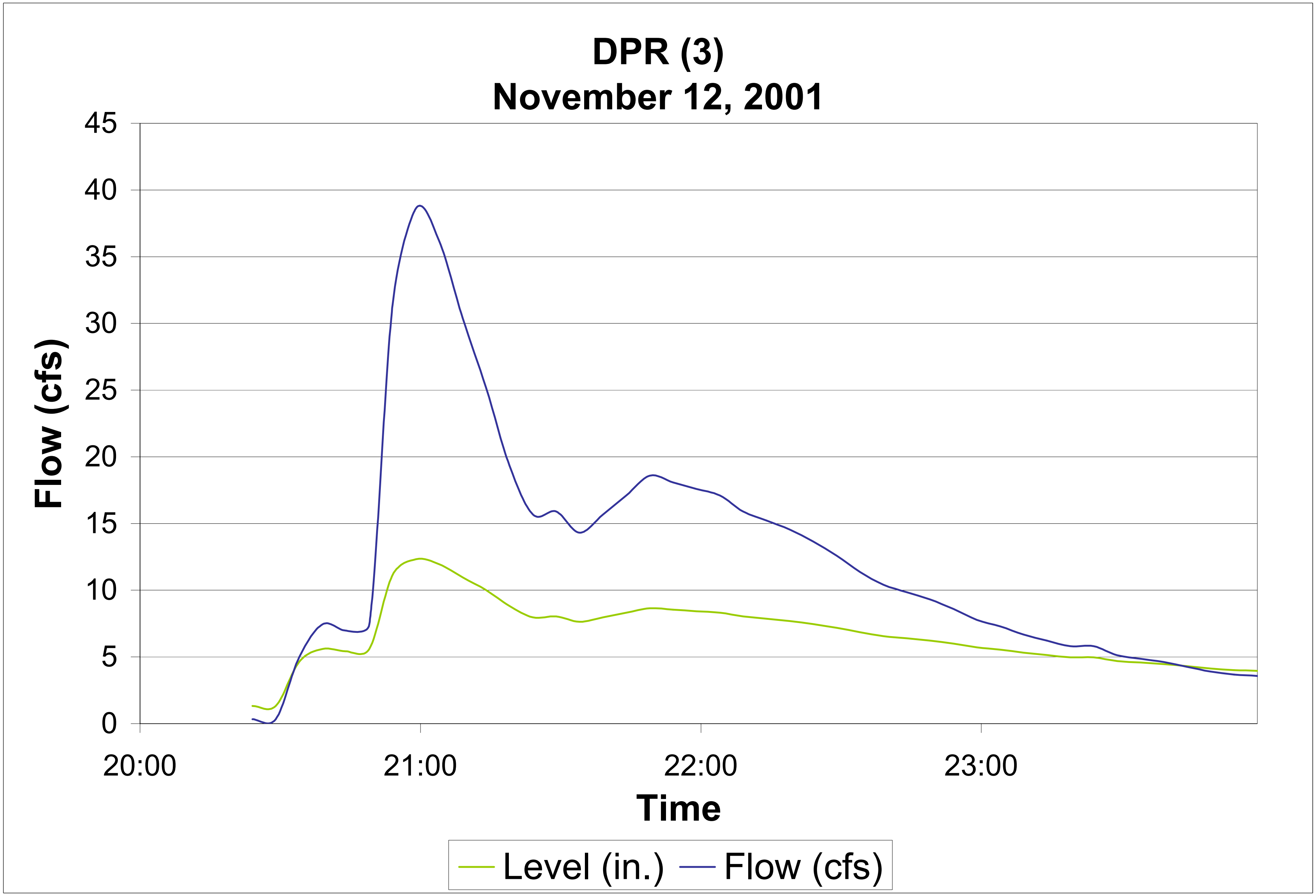
SD8 (5)
November 12, 2001
Flow (cfs)
140
120
100
80
60
40
20
0
20:00
21:00
22:00
23:00
Time
Level (in.)
Flow (cfs)

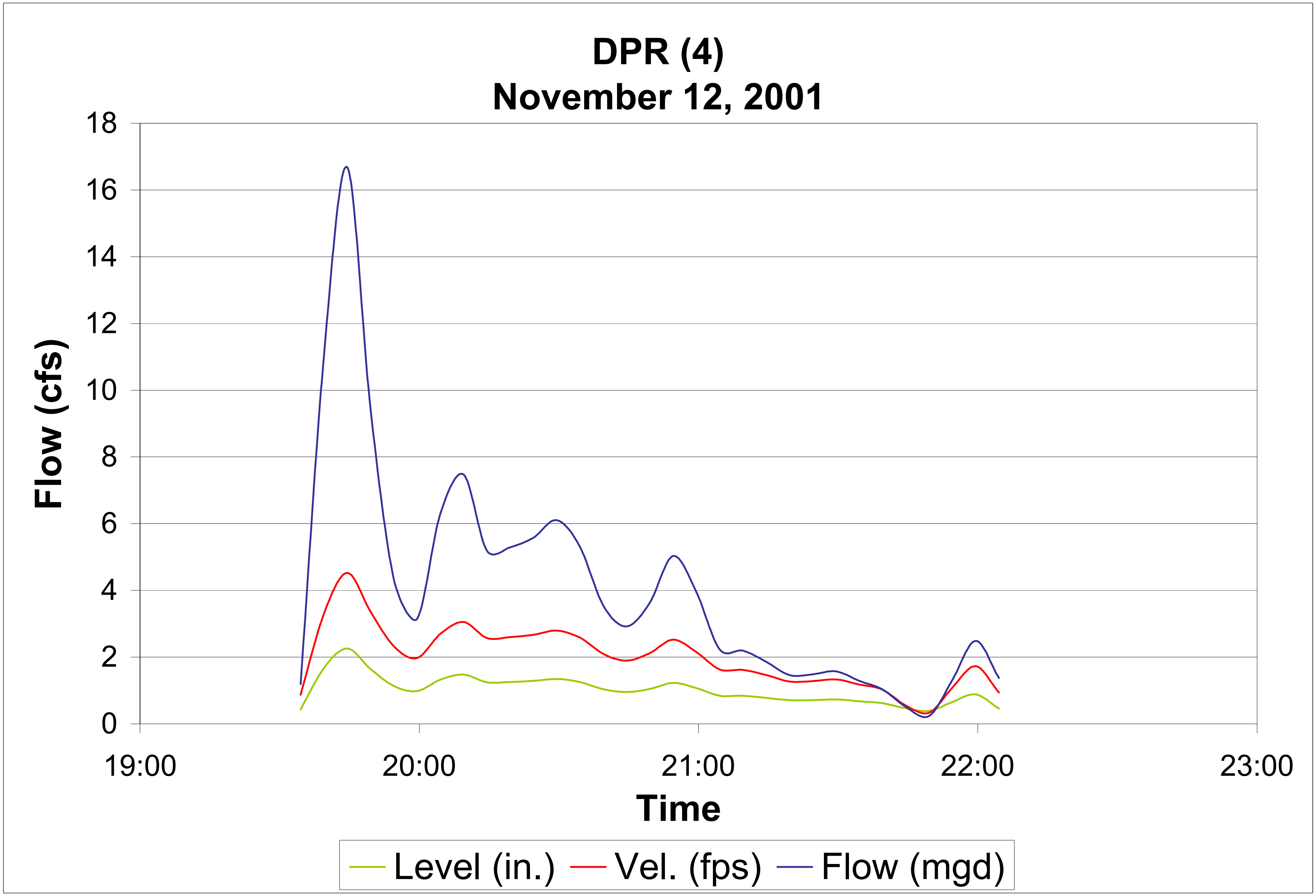

SD8 (6)
November 12, 2001
Flow (cfs)
25
20
15
10
5
0
21:30
22:00
22:30
23:00
23:30
0:00
Time
Level (in.)
Vel. (fps)
Flow (cfs)



DPR (1)
November 12, 2001
Flow (cfs)
50
45
40
35
30
25
20
15
10
5
0
20:00
21:00
22:00
23:00
Time
Level (in.)
Vel. (fps)
Flow (cfs)


DPR (2)
November 12, 2001
Flow (cfs)
250
200
150
100
50
0
22:00
22:30
23:00
23:30
0:00
Time
Level (in.)
Vel. (fps)
Flow (cfs)


DPR (3)
November 12, 2001
Flow (cfs)
45
40
35
30
25
20
15
10
5
0
20:00
21:00
22:00
23:00
Time
Level (in.)
Flow (cfs)



DPR (4)
November 12, 2001
Flow (cfs)
18
16
14
12
10
8
6
4
2
0
19:00
20:00
21:00
22:00
23:00
Time
Level (in.)
Vel. (fps)
Flow (mgd)